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National Nuclear Security Administration
Livermore Site Office, Livermore, California 94551

Lawrence Livermore National Laboratory 
Lawrence Livermore National Security, LLC, Livermore, California 94551
LLNL-AR-553611

**Second Five-Year Review Report for the High
Explosives Process Area Operable Unit at
Lawrence Livermore National Laboratory Site 300**

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November 12, 2012

*Weiss Associates, Emeryville, California



Environmental Restoration Department

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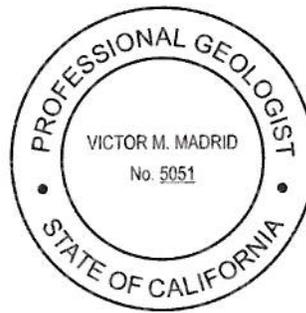
*Weiss Associates, Emeryville, California



Environmental Restoration Department

Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.



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**Approval for the
Second Five-Year Review for the High Explosives Process
Area Operable Unit at Lawrence Livermore National
Laboratory Site 300**

Prepared by:

United States Department of Energy
National Nuclear Security Administration
Livermore Site Office
Livermore, California

Approved:

 8-15-2013

Claire S. Holtzapple

Date

Site 300 Remedial Project Manager
U.S. Department of Energy
National Nuclear Security Administration
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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75 Hawthorne Street
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JUL 23 2013

Via USPS and email

Claire Holtzapple
U.S. Department of Energy
Livermore Environmental Programs Division
Lawrence Livermore National Laboratory
P.O. Box 808, L-574
Livermore, California 94551

Re: U.S. EPA Concurrence with Draft Final Second Five-Year Review Report for High Explosives Process Area Operable Unit, Lawrence Livermore National Laboratory Site 300, October 2012

Dear Ms. Holtzapple:

The U.S. Environmental Protection Agency ("EPA" or "Agency") has reviewed the Draft Final Second Five-Year Review Report for the High Explosives Process Area (HEPA) Operable Unit 4, at the Lawrence Livermore National Laboratory (LLNL) Site 300 ("Site") dated October 2012 ("Draft Final Report"). EPA appreciates that DOE has addressed the Agency's concerns with the Draft Final Report through submittal of the Response to Comments ("RTC") in December 2012 and subsequent correspondence. EPA agrees with the majority of the overall findings, conclusions and recommendations in the HEPA OU Draft Final Report, as modified by the RTCs, and concurs with the short and long-term protectiveness statements.

The remedy is protective of human health and the environment for the Site's industrial land use with respect to on-site workers in the short term. The remedy is protective of human health while the remedial systems are operating, and because exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of on-site institutional controls (ICs), the LLNL Site 300 Health and Safety Plan, and the LLNL Site 300 Contingency Plan.

The remedy is protective of human health and the environment for the Site's industrial land use with respect to on-site workers in the long term. The cleanup standards for groundwater are drinking water Maximum Contaminant Levels (MCLs). For contaminants in subsurface soil, the cleanup standards are based on the reduction of concentrations to mitigate risk to on-site workers and prevent further impacts to groundwater to the extent technically and economically feasible. Because some contaminants may remain in subsurface soil following the achievement of the soil cleanup standards, the Record of Decision requires implementation of a land use control that prohibits the transfer of lands with unmitigated contamination that may pose a threat to human health under residential or unrestricted land use. This prohibition must remain in place until and unless a risk assessment is performed in accordance with current EPA risk assessment guidance and is agreed to by the Department of Energy, EPA, and the State agencies as

adequately demonstrating no unacceptable risk for unrestricted use and unlimited exposure scenarios.

On the basis of the information presented in the HEPA OU Draft Final Five Year Review, EPA has made the following protectiveness determination:

The remedy at LLNL Site 300 protects human health and the environment in the short term because there is no current exposure pathways to site contamination and remedial treatment systems are effectively treating groundwater and soil gas. The remedy will protect human health and the environment in the long term because after the completion of active remedial activities Land Use Controls in the form of ICs will prevent exposure pathways until such time it is demonstrated that there no longer is a risk to human health from unrestricted use and unlimited exposure scenarios.

This Five-Year Review identifies one recommendation which will be implemented as part of the routine administrative or programmatic processes that are already in place to optimize the operation of the remedy. EPA understands that DOE will address our final comments with the inclusion of its December 2012 RTC submittal as an appendix to the final report. EPA also understands DOE has considered EPA's prior request to develop a formal plan and schedule consolidating the individual FYR documents, initially into two logical groupings, with the ultimate goal of producing one, site-wide document for future deliverables. Please provide us with the plan at your earliest convenience so that we may amend the FFA accordingly.

We appreciate the opportunity to work with you on this project and look forward to continued success at LLNL Site 300. If you have any questions regarding this letter, please feel free to contact Andrew Bain at (415) 972-3167.

Sincerely,



Michael M. Montgomery
Assistant Director, Superfund Division
Federal Facilities and Site Cleanup Branch

cc by email: Ariel Robertson, DOE
Leslie Ferry, LLNL
Jacinto Soto, DTSC
Aimee Phiri, CVRWQCB

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Lawrence Livermore National Laboratory Site 300, High Explosives Process Area Operable Unit (OU)		
EPA ID: CA 2890090002		
Region: IX	State: California	City/County: San Joaquin/Alameda
SITE STATUS		
NPL status: Final		
Multiple OUs: Yes	Has the site achieved construction completion? Yes. September 2007	
REVIEW STATUS		
Lead agency: United States (U.S.) Department of Energy (DOE)		
Author name: A. Helmig		
Author title: Project Hydrogeologist	Author affiliation: Weiss Associates- Emeryville, California	
Review period: September 2006 to September 2011		
Date(s) of site inspection: March 31, 2011		
Type of review: Statutory		
Review number: 2		
Triggering action date: 2007 Five-Year Review for the High Explosives Process Area OU		
Due date: November 12, 2012		

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
Not applicable.				
Issues/Recommendations Identified in the Five-Year Review:				
OU(s): 4	Issue Category: No Issue Issue: The remedy is performing as intended and is demonstrating good progress in remediating the ground water. To further expedite the ground water cleanup, some follow-up actions are recommended. Recommendation #1: Install one new extraction well (W-815-2803) to increase hydraulic capture and mass removal in the Building 815 source area and to prevent migration of volatile organic compounds (VOCs), high explosive (HE) compounds, and perchlorate in the Tnbs ₂ hydrostratigraphic unit (HSU). This extraction well will be connected to the Building 815-Source (815-SRC) treatment facility.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2014
OU(s): 4	Issue Category: No Issue Issue: NA Recommendation #2: Convert Tnbs ₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent further offsite migration of VOCs, and connect it to the 815-Distal Site Boundary (DSB) ground water treatment system.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2012

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS (Continued)				
OU(s): 4	Issue Category: No Issue			
	Issue: NA			
	Recommendation #3: Evaluate Tnbs ₂ HSU monitor well W-815-2621 to determine its suitability as an extraction well for the 815-DSB wellfield.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2016
OU(s): 4	Issue Category: No Issue			
	Issue: NA			
	Recommendation #4: Install one new well (W-817-2XM1) to monitor HE compounds, perchlorate, and nitrate concentrations near the 817-SRC treatment facility in the Tnbs ₂ HSU. This monitor well will assess the effectiveness of the 817-SRC recirculation cell between extraction well W-817-01 and effluent injection well W-817-06A.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2014
OU(s): 4	Issue Category: No Issue			
	Issue: NA			
	Recommendation #5: Install one new well (W-815-2XM1) to monitor VOCs, HE compounds, perchlorate, and nitrate concentrations near the Building 815 source area in the Tpsg-Tps HSU.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2014

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS (Continued)				
OU(s): 4	Issue Category: No Issue			
	Issue: NA			
	Recommendation #6: Evaluate Tnbs ₂ HSU well W-817-2609 in the 817-Proximal area by monitoring contaminant concentrations in this well and nearby well W-817-03 to determine whether to convert well W-817-2609 to an extraction well			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2016
OU(s): 4	Issue Category: No Issue			
	Issue: NA			
	Recommendation #7: Identify potential locations for two additional effluent injection wells to allow 817-PRX wellfield extraction rates to be increased in the Tnbs ₂ HSU.			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	No	Federal Facility	EPA/State	September 2016

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS (Continued)				
OU(s): 4	Issue Category: Institutional Controls			
	<p>Issue: A VOC plume in the Tnbs₂ HSU with concentrations above Maximum Contaminant Level (MCL) cleanup standards originating from the HEPA OU extends approximately 100 feet offsite in the vicinity of monitor wells W_35B 04 and -05. While active private offsite water-supply well GALLO1 is located upgradient from the VOC plume, an evaluation of ground water elevation data indicate that the pumping of GALLO1 is drawing the VOC plume towards it. Historically, TCE has been sporadically detected at low concentrations (<1 µg/L) above the 0.5 µg/L reporting limit but below the 5 µg/L drinking water MCL cleanup standard in ground water samples in offsite water-supply well GALLO1.</p> <p>There is no Memorandum of Understanding (MOU) and/or other institutional controls to prevent the installation of offsite water-supply or agricultural wells within the offsite portion of the VOC plume originating from the HEPA OU. In addition, while LLNL notified the owner of TCE detections in GALLO1 and DOE offered to provide point-of-use treatment at this well, there is no Memorandum of Understanding (MOU) that formally documents that DOE would provide point-of-use treatment at GALLO1 to prevent the consumption of contaminated water from this well.</p>			
	<p>Recommendation #8: DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend that the property owner include a provision in the MOU to formally document that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1.</p>			
Affect Current Protectiveness	Affect Future Protectiveness	Implementing Party	Oversight Party	Milestone Date
No	Yes	Federal Facility	EPA/State	November 8, 2012

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT		
OU: 4	Protectiveness Determination Protective	Addendum Due Date: NA
<p>Protectiveness Statement: The remedy at the HE Process Area OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination and remedial treatment systems are effectively treating ground water. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. However, in order for the remedy to be protective in the long-term, institutional controls will be implemented to prevent potential future exposure to offsite ground water contamination.</p> <p>A VOC plume in the Tnbs₂ HSU with concentrations above MCL cleanup standards originating from the HEPA OU extends approximately 100 feet offsite in the vicinity of monitor wells W-35B-04 and -05. While active private offsite water-supply well GALLO1 is located upgradient from the VOC plume, an evaluation of ground water elevation data indicate that the pumping of GALLO1 is drawing the VOC plume towards it. Historically, TCE has been sporadically detected at low concentrations (<1 µg/L) above the 0.5 µg/L reporting limit but below the 5 µg/L drinking water MCL cleanup standard in ground water samples in offsite water-supply well GALLO1.</p> <p>There is no MOU and/or other institutional controls to prevent the installation of offsite water-supply or agricultural wells within the offsite portion of the VOC plume originating from the HEPA OU. In addition, while LLNL notified the owner of TCE detections in GALLO1 and DOE offered to provide point-of-use treatment at this well, there is no Memorandum of Understanding (MOU) that formally documents that DOE would provide point-of-use treatment at GALLO1 to prevent the consumption of contaminated water from this well.</p> <p>Therefore, DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend that the property owner include a provision in the MOU to formally document that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1. The remedy will be protective in the long-term, once the MOU is in place.</p> <p>The cleanup standards for HEPA OU ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.</p> <p>The cleanup standards for VOCs in subsurface soil are to reduce concentrations to mitigate risk to onsite workers and prevent further impacts to ground water to the extent technically and economically feasible. Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with</p>		

unmitigated contamination that could cause potential harm under residential or unrestricted land use. The land use control consists of implementing a land use covenant per Title 22 California Code of Regulations (CCR), Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h) in the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future. This land use control requirement is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, Department of Toxic Substances Control (DTSC), and Regional Water Quality Control Board (RWQCB) agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

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- Table 4. Contaminants of Concern, Startup Dates, Extraction Wells, and Hydrostratigraphic Unit (HSU) Completion for the HEPA Ground Water Extraction and Treatment Systems.

Appendices

- Appendix A. Ground Water Flow and Contaminant Transport Modeling in the Tnbs₂ Hydrostratigraphic Unit.

Attachments

- Attachment A. High Explosives Process Area Operable Unit Five-Year Review Inspection Checklist.
- Attachment B. Responses to Regulatory Comments.

1. Introduction

The United States (U.S.) Department of Energy (DOE)/National Nuclear Security Administration (NNSA) has conducted a Five-Year Review of the remedial actions implemented at the High Explosives Process Area (HEPA) Operable Unit (OU) at Lawrence Livermore National Laboratory (LLNL) Site 300. Environmental cleanup is conducted under the oversight of the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) – Central Valley Region. DOE/NNSA is the lead agency for environmental restoration at LLNL. The review documented in this report was conducted from September 2006 through September 2011. Parties providing analyses in support of the review include:

- U.S. DOE/NNSA, Livermore Site Office.
- LLNL, Environmental Restoration Department (ERD).
- Weiss Associates.

The purpose of a Five-Year Review is to evaluate the implementation and performance of a remedy to determine whether the remedy is currently protective and will continue to be protective of human health and the environment. The Five-Year Review report presents the methods, findings, and conclusions of the review. In addition, the Five-Year Review identifies issues or deficiencies in the selected remedy, if any, and presents recommendations to address them. The format and content of this document is consistent with guidance issued by DOE (DOE, 2002) and the U.S. EPA (EPA, 2001).

Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendment Reauthorization Act (SARA), requires that remedial actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. The National Contingency Plan further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment. Consistent with Executive Order 12580, Federal agencies are responsible for ensuring that Five-Year Reviews are conducted at sites where five-year reviews are required or appropriate.

LLNL Site 300 (Figure 1) has been divided into nine Operable Units (OUs) based on the nature and extent of contamination to effectively manage site cleanup (Figure 2):

- General Services Area (GSA) (OU 1) including the Central and Eastern GSA.
- Building 834 (OU 2).
- Pit 6 Landfill (OU 3).
- High Explosives (HE) Process Area (OU 4) including Building 815, the HE Lagoons, and the HE Burn Pit.
- Building 850/Pit 7 Complex (OU 5).
- Building 854 (OU 6).
- Building 832 Canyon (OU 7) including Buildings 830 and 832.

- Site-Wide (OU 8) including Buildings 801, 833, 845, and 851 and the Pit 2, 8, 9 Landfills.
- Building 812 (OU 9).

Five-year reviews are conducted individually for each OU at Site 300, except for OUs 3 and 8. The Construction Completion Report (Holtzapple, 2008) and Site-Wide Record of Decision (ROD) (U.S DOE, 2008) are the triggers for the five-year reviews for OUs 3 and 8, respectively, in accordance with EPA guidance. At the other OUs where construction began prior to the Site-Wide ROD as treatability studies and/or removal actions, DOE/NNSA and the regulatory agencies agreed to use the completion of the OU-specific Remedial Design reports as the triggers for the first five-year reviews.

This is the second Five-Year Review for the HEPA OU (OU 4). The first Five-Year Review was completed in 2007 (Dibley et al., 2007b). This review is considered a statutory review because: (1) contamination will remain onsite upon completion of the remedial action, (2) the Record of Decision was signed after October 17, 1986 (the effective date of the SARA), and (3) the remedial action was selected under the CERCLA. The triggering action for the first review was the August 15, 2002 submittal date of the Interim Remedial Design for the High Explosives Process Area Operable Unit at Lawrence Livermore National Laboratory Site 300 (Madrid et al., 2002).

The background and description of the HEPA OU are presented in Section 3. The following sections include the descriptions and status of the other OUs and areas where environmental restoration activities are occurring at Site 300.

1.1. General Services Area (GSA) OU (OU 1)

The GSA OU has been separated into the Central GSA and the Eastern GSA based on differences in hydrogeology and the distribution of environmental contaminants. DOE/NNSA has performed three Five-Year Reviews for the GSA OU (Ferry et al., 2001b; Dibley et al., 2006a; and Valett et al., 2011). The fourth Five-Year Review is scheduled for 2016.

1.1.1. Central GSA

Chlorinated solvents, mainly trichloroethene (TCE), were used as degreasing agents in craft shops in the Central GSA. Rinse water from these degreasing operations was disposed of in dry wells that were gravel-filled holes about 3 to 4 feet (ft) deep and 2 ft in diameter. As a result, subsurface soil and ground water were contaminated with volatile organic compounds (VOCs). There are no contaminants of concern (COCs) in surface soil in the central GSA. The Central GSA dry wells were used until 1982. In 1983 and 1984, these dry wells were decommissioned and excavated.

Ground water cleanup began in the Central GSA in 1992 and soil vapor extraction started in 1994 as removal actions. In 1997, a Final ROD for the GSA OU (U.S. DOE, 1997) was signed and ground water and soil vapor extraction and treatment continued as a remedial action. The selected remedy for the Central GSA includes monitoring, risk and hazard management, and ground water and soil vapor extraction and treatment. The remedial design was completed in 1998 and construction completion for the OU was documented in September 2005.

Operation of the ground water and soil vapor extraction and treatment systems to remove VOCs from the subsurface is ongoing. Remediation has reduced maximum VOC concentrations in ground water from 272,000 micrograms per liter ($\mu\text{g/L}$) to 700 $\mu\text{g/L}$ (April 2011) and has mitigated the risk to onsite workers from inhalation of VOCs inside Building 875.

1.1.2. Eastern GSA

The source of contamination in the Eastern GSA is an abandoned debris burial trench that received craft shop debris. Leaching of solvents from the debris resulted in the release of VOCs to ground water.

Ground water cleanup began in the Eastern GSA in 1991 as a removal action. In 1995, a Final ROD for the GSA OU was signed and ground water extraction and treatment continued as a remedial action. The remedial design was completed in 1998 and construction completion for the OU was documented in September 2005. A ground water extraction and treatment system operated from 1991 to 2007 to remove VOCs from ground water.

By 2005, VOC concentrations in both onsite and offsite ground water in the Eastern GSA area had been reduced to below the drinking water Maximum Contaminant Level (MCL) cleanup standards. In February 2007, the ground water extraction and treatment system was shut down with regulatory concurrence. DOE/NNSA continued to monitor ground water for five years, during which time VOC concentrations remained below the MCL cleanup standards, indicating that ground water cleanup had been successfully completed in the Eastern GSA.

1.2. Building 834 (OU 2)

From 1962 to 1978, intermittent spills and piping leaks resulted in contamination of the subsurface soil and rock and ground water with VOCs and silicone oils (tetrabutyl orthosilicate/tetrakis (2-ethylbutyl) silane [TBOS/TKEBs]). Nitrate in ground water results from septic system effluent but may also have natural sources. There are no COCs in surface soil.

Completed remedial activities include excavating VOC-contaminated soil (1983) and installing a surface water drainage diversion system to prevent rainwater infiltration in the contaminant source area (1998). Ground water and soil vapor extraction and treatment began in 1986 as treatability studies. An area-specific Interim ROD for the Building 834 OU (U.S. DOE, 1995) was superseded by the Interim Site-Wide ROD and subsequent 2008 Site-Wide ROD. The Building 834 OU remedy includes monitoring, risk and hazard management, and ground water and soil vapor extraction and treatment. Significant *in situ* bioremediation is occurring in Building 834 ground water and a treatability study focusing on understanding and enhancing this process has been conducted. The remedial design was completed in 2002 and construction completion for the OU was achieved in September 2005.

Remediation has reduced VOC concentrations in ground water from a historical maximum of 1,060,000 $\mu\text{g/L}$ to a maximum of 210,000 $\mu\text{g/L}$ in February 2011. TBOS/TKEBs in ground water has also been reduced from a historic maximum concentration of 7,300,000 $\mu\text{g/L}$ in 1995 to 4,800 $\mu\text{g/L}$ (February 2011). While nitrate concentrations have decreased from a historic maximum of 749 milligrams per liter (mg/L) in 2000 to 300 mg/L (February 2011), the continued elevated nitrate concentrations indicate an ongoing source of ground water nitrate. It is likely that there are multiple sources of nitrate at Building 834. One possible anthropogenic source is the septic system leachfield located in the vicinity of wells W-834-S1. A second

probable source is natural soil nitrate. Additional sources could be nitrogenous compounds, like nitric acid or barium nitrate, that might have inadvertently been discharged into the septic system via a test cell floor drain or to the ground during accidental spills and/or pipeline leaks that released TCE to the environment. Anaerobic bacteria in the Building 834 Core and T2 areas reduce nitrate locally by denitrification.

DOE/NNSA has performed three Five-Year Reviews for the Building 834 OU (Ferry et al., 2002a, Dibley et al., 2007a, and Valett et al., 2012).

1.3. Pit 6 Landfill (OU 3)

From 1964 to 1973, approximately 1,900 cubic yards (yd³) of waste from LLNL Livermore Site and Lawrence Berkeley Laboratory was buried in nine unlined trenches and animal pits at the Pit 6 Landfill. Infiltrating rainwater leached contaminants from pit waste resulting in tritium, VOC, and perchlorate contamination in ground water. Nitrate contamination in ground water results from septic system effluent. No COCs were identified in surface or subsurface soil.

In 1971, DOE excavated portions of the waste contaminated with depleted uranium. In 1997, a landfill cap was installed as a CERCLA removal action to prevent infiltrating precipitation from further leaching contaminants from the waste. Because of decreasing VOC concentrations in ground water, the presence of trichloroethene (TCE) degradation products, and the short half-life of tritium (12.3 years), the selected remedy for VOCs and tritium at the Pit 6 Landfill is monitored natural attenuation (MNA). Because ground water monitoring data for perchlorate and nitrate are limited, DOE/NNSA will continue to monitor ground water to determine if and when an active remedy for these contaminants might be necessary. The remedy also includes risk and hazard management. Construction completion was achieved in October 2002. No Remedial Design document was required for this area.

The extent of contamination at the Pit 6 Landfill is limited and continues to decrease with concentrations/activities near and below cleanup standards. Natural attenuation has reduced total VOCs in ground water from a historic maximum of 250 µg/L in 1988 to a first semester 2011 maximum concentration of 9.3 µg/L (April 2011). Tritium activities are well below the cleanup standard and continue to decrease towards background levels. Perchlorate is not currently detected in any wells above the 4 µg/L reporting limit. The extent of nitrate at concentrations exceeding the cleanup standard continues to be limited to one well. Installation of the landfill cap mitigated the onsite worker inhalation risk.

The first Five-Year Review for this OU is scheduled for 2012.

1.4. Building 850/Pit 7 Complex (OU 5)

This OU has been divided into two areas for cleanup evaluation purposes: (1) the Building 850 Firing Table area, and (2) the Pit 7 Complex.

A Remedial Action Completion Report for the Building 850/Pit 7 Complex OU was completed in 2011 (Dibley et al., 2011b). The first Five-Year Review for this OU is scheduled for 2016.

1.4.1. Building 850 Firing Table (OU 5)

High-explosives experiments were conducted at the Building 850 Firing Table from 1958 to 2008. Tritium was used in some of these experiments, primarily between 1963 and 1978. As a result of the destruction and dispersal of test assembly debris during detonations, surface soil was contaminated with metals, polychlorinated biphenyls (PCBs), dioxins, furans, High-Melting Explosive (HMX), and depleted uranium. Leaching from firing table debris has resulted in tritium and depleted uranium contamination in subsurface soil and ground water. Nitrate and perchlorate are also COCs in ground water. Tritium is the only COC in surface water (Well 8 Spring).

Gravel was removed from the firing table in 1988 and placed in the Pit 7 Landfill. PCB-contaminated shrapnel and debris were removed from the area around the firing table in 1998. The Building 850 remedy consists of MNA, monitoring, and risk and hazard management. A remedial design was completed in 2004. The remedial design included the excavation and offsite disposal of contaminated surface soil and sand pile. This remedy was not implemented due to a large increase in transportation and offsite disposal costs. DOE and the regulatory agencies agreed to perform remediation of contaminated surface soil as a non-time critical removal action. An Engineering Evaluation/Cost Analysis (Dibley et al., 2008a) and Action Memorandum (Dibley et al., 2008b) were completed in 2008. A removal action was completed in 2010 for the excavation and solidification of PCB-, dioxin-, and furan-contaminated soil and sand pile. Metals, HMX, and uranium in surface soil at Building 850 do not pose a risk to human health or threat to ground water, therefore a no further action remedy was selected. However, these constituents in surface soil were removed during the soil excavation/solidification removal action.

Natural attenuation has reduced tritium activities from a historic maximum of 566,000 picoCuries per liter (pCi/L) in 1985 to a first semester 2011 maximum of 53,300 pCi/L (May 2011). Uranium activities are below the cleanup standard and are within the range of natural background levels. The extent of nitrate with concentrations above cleanup standards is limited and does not pose a threat to human health or the environment. The maximum perchlorate concentration in the first semester 2011 is 74 µg/L (April 2011), and a treatability study to evaluate *in situ* biodegradation of perchlorate is in progress.

1.4.2. Pit 7 Landfill Complex (OU 5)

The Pit 3, 4, 5, and 7 Landfills are collectively designated the Pit 7 Landfill Complex. Firing table debris containing tritium, depleted uranium, and metals was placed in the pits in the 1950s through the 1980s. The Pit 4 and 7 Landfills were capped in 1992. During years of above-normal rainfall (i.e., 1997-1998 El Niño event), ground water rose into the bottom of the landfills and the underlying contaminated bedrock. This resulted in the release of tritium, uranium, VOCs, perchlorate, and nitrate to ground water. There are no COCs in surface water or surface soil. Tritium and depleted uranium are COCs in subsurface soil.

DOE and the regulatory agencies agreed that the Pit 7 Complex required additional study; accordingly, this area was not included in the 2001 Interim ROD and an area-specific Remedial Investigation/Feasibility Study (Taffet et al., 2005) was completed. An Amendment to the Interim ROD for the Pit 7 Complex was signed in 2007 (U.S. DOE, 2007) that described the selected remedy for the Pit 7 Complex including monitoring, risk and hazard management,

MNA, ground water extraction and treatment, and source control. The interim remedial design was completed in 2008. A hydraulic drainage diversion system was constructed in 2008 to control contaminant sources by preventing ground water from rising into the pit waste and underlying contaminated bedrock. Also, a ground water extraction and treatment system was constructed in 2009-2010 to treat uranium, nitrate, perchlorate, and VOCs in ground water.

Natural attenuation has reduced tritium activities in ground water from a historic maximum of 2,660,000 pCi/L in 1998 to a first semester 2011 maximum of 575,000 pCi/L (April 2011) and has mitigated risk to onsite workers from inhalation of tritium vapors. Uranium activities have also decreased from a historic maximum of 781 pCi/L in 1998 to a first semester 2011 maximum of 172 pCi/L (April 2011). VOC concentrations are currently near or below cleanup standards. Nitrate concentrations in ground water remain relatively stable, while perchlorate concentrations have decreased.

1.5. Building 854 (OU 6)

TCE was released to soil and ground water through leaks and discharges of heat-exchange fluid, primarily between 1967 and 1984. Nitrate and perchlorate are also COCs in ground water. HE compounds, PCBs, dioxins, furans, tritium, and metals were identified as COCs in surface soil. No further action was selected as the remedy for metals, HMX, and tritium in surface soil.

In 1983, TCE-contaminated soil was excavated at the northeast corner of Building 854F. Ground water extraction and treatment has been conducted since 1999 to reduce VOC, nitrate, and perchlorate concentrations in ground water. PCB-, dioxin-, and furan-contaminated soil in the Building 855 former rinse water lagoon was excavated in 2005 (Holtzapple, 2005). The selected remedy for this OU includes monitoring, risk and hazard management, and ground water and soil vapor extraction and treatment. The interim remedial design was completed in 2003. Construction completion for the OU was achieved in September 2007. Three ground water extraction and treatment systems and one soil vapor extraction and treatment system currently operate in the OU.

Ground water remediation has reduced total VOC concentrations from a historic maximum of 2,900 µg/L in 1997 to a first semester 2011 maximum of 110 µg/L (April 2011). Nitrate concentrations have decreased from a historic maximum of 260 mg/L in 2003 to a first semester 2011 maximum of 50 mg/L (June 2011). Perchlorate concentrations in ground water have also decreased from 27 µg/L in 2003 to a first semester 2011 maximum of 15.9 µg/L (June 2011). Risks to onsite workers from inhalation of VOC vapors and from exposure to PCBs, dioxins, and furans in surface soil have been mitigated.

A Five-Year Review of remediation in the Building 854 OU was completed in January 2009 (Dibley et al., 2009a). The second Five-Year-Review is scheduled for 2014.

1.6. Building 832 Canyon (OU 7)

Contaminants were released from Buildings 830 and 832 through piping leaks and surface spills during past activities at these buildings. VOCs, nitrate, and perchlorate are the COCs in ground water. VOCs are the COCs in surface water at Spring 3. VOCs, nitrate, and HMX are the COCs in subsurface soil. HMX is also a COC in surface soil. No further action was selected as the remedy for HMX and nitrate in surface and subsurface soil.

Ground water and soil vapor extraction and treatment have been conducted since 1999 to reduce contamination in ground water and subsurface soil. The Building 832 Canyon OU remedy includes monitoring, risk and hazard management, MNA for nitrate, and ground water and soil vapor extraction and treatment. The interim remedial design was completed in 2006. Construction completion for the OU was achieved in September 2007. Three ground water extraction and treatment systems and two soil vapor extraction and treatment systems currently operate in this OU.

Remediation has reduced total VOC concentrations from a historical maximum of 13,000 µg/L in 2003 to a first semester 2011 maximum of 3,600 µg/L (April 2011). Perchlorate concentrations have been reduced from a historical maximum of 51 µg/L in 1998 to a first semester 2011 maximum of 14 µg/L (March 2011). Nitrate concentrations in ground water remain fairly stable, and are possibly the result of the ongoing contribution of nitrate from septic systems and natural bedrock sources. Nevertheless, natural denitrification processes continue to reduce nitrate concentrations to background levels near the site boundary. Remediation has also mitigated the risk to onsite workers in several locations in the Building 832 Canyon OU.

A Five-Year Review of remediation in the Building 832 Canyon OU was completed in August 2011 (Helmig et al., 2011). The second Five-Year-Review is scheduled for 2016.

1.7. OU 8

Operable Unit 8 includes the contaminant release sites that have a monitoring-only remedy: the Building 801 Dry Well and Pit 8 Landfill, Building 833, Building 845 and Pit 9 Landfill, the Building 851 Firing Table, and the Pit 2 Landfill. OU 8 release sites have a monitoring-only interim remedy because either: (1) contaminants in surface and subsurface soil/bedrock do not pose a risk to humans or plant and animal populations or a threat to ground water, (2) there is no ground water contamination, (3) contaminant concentrations in ground water do not exceed cleanup standards, and/or (4) the extent of contamination in ground water is limited. The first Five-Year Review for this OU is scheduled for 2013. These release sites are summarized below.

1.7.1. Building 801 Dry Well and the Pit 8 Landfill (OU 8)

The Building 801 Firing Table was used for explosives testing and operations resulting in contamination of adjacent soil with metals and uranium. Use of this firing table was discontinued in 1998, and the firing table gravel and some underlying soil were removed. Waste fluid was discharged to a dry well (sump) located adjacent to Building 801D from the late 1950s to 1984. The dry well was decommissioned and filled with concrete in 1984. VOCs, perchlorate and nitrate are COCs in ground water due to the past releases from the Building 801 Dry Well. VOC and nitrate concentrations in ground water are currently near or below cleanup standards or at background levels. Perchlorate is not currently detected in ground water. VOCs are COCs in subsurface soil, but do not pose a risk to human health. The adjacent Pit 8 Landfill received debris from the Building 801 Firing Table until 1974, when it was covered with compacted soil. There is no evidence of contaminant releases from the landfill.

The selected remedy for this area includes monitoring and risk and hazard management. No further action was selected as the remedy for VOCs in subsurface soil at Building 801.

No Remedial Design documents are required for this area.

1.7.2. Building 833 (OU 8)

TCE was used as a heat-exchange fluid in the Building 833 area from 1959 to 1982 and was released through spills and rinse water disposal, resulting in TCE-contamination of subsurface soil and shallow perched ground water. No contamination has been detected in the deeper regional aquifer. No COCs were identified surface soil at Building 833.

The selected remedy for Building 833 includes monitoring and risk and hazard management. No Remedial Design document is required for this area. Ground water monitoring at Building 833 has shown a decline in total VOC concentrations from a historic maximum of 2,100 µg/L in 1992 to a first semester 2011 maximum of 150 µg/L (February 2011).

1.7.3. Building 845 Firing Table and the Pit 9 Landfill (OU 8)

The Building 845 Firing Table was used from 1958 until 1963 to conduct explosives experiments. Leaching from firing table debris resulted in minor contamination of subsurface soil with depleted uranium and HMX but no unacceptable risk to human or ecological receptors or threat to ground water was identified. No contaminants have been detected in surface soil or in ground water at the Building 845 Firing Table. Debris generated at the Building 845 Firing Table was buried in the Pit 9 Landfill. There has been no evidence of contaminant releases from the Pit 9 Landfill.

The selected remedy for Building 845 and the Pit 9 Landfill includes monitoring and risk and hazard management. No further action was selected as the remedy for uranium and HMX in subsurface soil at Building 845. No Remedial Design documents are required for this area.

1.7.4. Building 851 Firing Table (OU 8)

The Building 851 Firing Table has been used for high-explosives research since 1962. VOCs and uranium-238 were identified as COCs in subsurface soil, and Research Department explosive (RDX), uranium-238, and metals as surface soil COCs. However, there is no risk to humans or animal populations, or threat to ground water associated with these contaminants in surface and subsurface soil. Uranium-238 was identified as a COC in ground water. However, it poses no risk to human or ecological receptors, and uranium activities are well below cleanup standards and within the range of background levels.

In 1988, the firing table gravel was removed and disposed in Pit 7. Gravel has been replaced periodically since then. The selected remedy for Building 851 includes monitoring and risk and hazard management. No further action was selected as the remedy for VOCs and uranium in surface and subsurface soil, and for RDX and metal in surface soil at Building 851. No Remedial Design document is required for this area.

1.7.5. Pit 2 Landfill (OU 8)

The Pit 2 Landfill was used from 1956 until 1960 to dispose of firing table debris from Buildings 801 and 802. Ground water data indicate a discharge of potable water to support a red-legged frog habitat located upgradient from the landfill may have leached depleted uranium from the buried waste. The frogs were relocated and the water discharge was discontinued, thereby removing the leaching mechanism. No contaminants were identified in surface or subsurface soil at the Pit 2 Landfill. No risk to human or ecological receptors has been identified at the Pit 2 Landfill.

The selected remedy for the Pit 2 Landfill includes monitoring and risk and hazard management. Monitoring data indicate that uranium activities remain below the cleanup standard. No Remedial Design document is required for this area.

1.8. Building 812 (OU 9)

The Building 812 Complex was built in the late 1950s-early 1960s and was used to conduct explosives tests and diagnostics until 2008. A Characterization Summary Report for this area was completed in 2005 (Ferry and Holtzapple, 2005). The Building 812 Complex was designated as OU 9 in March 2007 based on characterization results that indicated the presence of uranium, VOCs, HE compounds, nitrate, and perchlorate in environmental media. In 2008, a draft Remedial Investigation/Feasibility Study (RI/FS) describing the results of characterization activities and remedial alternatives for the Building 812 OU was submitted to the regulatory agencies. A DOE task force reviewed the soil-washing alternative and determined that it would not be effective at Site 300; therefore a soil-washing treatability study will not be performed. DOE is currently evaluating a new remedial strategy for contaminated soil at Building 812. Additional characterization began in 2011. A new RI/FS will be prepared following the completion of the characterization. A Proposed Plan will subsequently present the alternatives and a preferred remedy for public comment. A remedy will then be selected in an Amendment to the Site-Wide ROD.

1.9. Building 865/Advanced Test Accelerator

Building 865 facilities were used to conduct high-energy laser tests and diagnostics in support of national defense programs from 1980 to 1995. The Building 865 Complex housed a 275-foot linear electron accelerator called the Advanced Test Accelerator (ATA). The ATA was designed to produce a repetitively pulsed electron beam for charged particle beam research. In 2006, a Characterization Summary Report for this area was submitted to the regulatory agencies (Ferry and Holtzapple, 2006). Freon 113, Freon 11, and tetrachloroethene (PCE) were identified as COCs in ground water. However, concentrations of Freon 11 and 113 are well below their MCLs; and PCE is only detected in one well at a concentration above its MCL. The remediation pathway for Building 865 is currently being negotiated.

2. Site Chronology

The chronology of key HEPA OU environmental restoration events is summarized below.

1958–1989

- Surface spills at the drum storage and dispensing area for the former Building 815 steam plant resulted in TCE released to the ground surface until use of this area was discontinued in 1986.
- Waste fluids were discharged to dry well 810A from 1959 to 1985 resulting in release of VOCs to the subsurface.
- Wastewater containing HE compounds, nitrate, and perchlorate was discharged to former unlined rinsewater lagoons from the mid-to-late 1950s to 1985. Unlined HE rinsewater

lagoons were capped and closed between 1985 and 1989. Two double-lined surface impoundments were installed in 1984.

- TCE was detected in ground water collected in former onsite water-supply Well 6 in 1982. In 1989, Well 6 was destroyed and replaced with Well 20.

1990

- LLNL Site 300 was placed on the National Priorities List.

1992

- A Federal Facilities Agreement for Site 300 was signed.

1994

- The Site-Wide Remedial Investigation report for Site 300 was issued (Webster-Scholten et al., 1994).

1998

- The Building 815 Operable Unit Engineering Evaluation/Cost Analysis (Madrid and Jakub, 1998) proposed a Removal Action involving installation of ground water compliance monitoring wells and ground water extraction and treatment from onsite wells to prevent offsite migration of TCE.
- An Action Memorandum for the Building 815 Removal Action (Jakub, 1998) authorized an early phase of ground water cleanup as a Non Time-Critical Removal Action.
- Capping and closure of the HE Burn Pit was completed in 1998. These pits, located in the vicinity of Building 829, had been used to burn HE particulates and cuttings, explosive chemicals, and explosives-contaminated debris from the late 1950s until 1998.

1999

- The Site-Wide Feasibility Study for Site 300 was issued (Ferry et al., 1999).
- Ground water extraction and treatment was initiated in the distal portion of the Building 815 VOC plume near the site boundary to prevent offsite plume migration.

2000

- Ground water extraction and treatment was initiated in the Building 815 source area.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified continued ground water and soil vapor extraction, administrative controls (e.g., risk and hazard management), monitoring, and no further action for: (1) VOCs in soil and bedrock at the HE rinsewater lagoons, and (2) VOCs and high melting explosive/research department explosive (HMX/RDX) in soil and bedrock at the HE Burn Pit, as the components of the selected interim remedy for the HEPA OU. The Interim Site-Wide ROD did not contain ground water cleanup standards. These standards were established in the 2008 Final Site-Wide ROD for Site 300.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD (Ferry et al., 2001b).

2002

- The Interim Remedial Design Report for the HEPA OU was issued.

- The Compliance Monitoring Plan/Contingency Plan for the interim remedies was issued (Ferry et al., 2002b).
- Ground water extraction and treatment was initiated in the proximal portion of Building 815 plume.

2003

- Ground water extraction and treatment was initiated in the Building 817 source area.

2005

- Ground water extraction and treatment was initiated in the Building 829 source area.
- Ground water extraction and treatment was initiated in Building 817 proximal area.
- The HE surface impoundments south of Building 817 were closed.

2007

- The first HEPA OU Five-Year Review was issued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy for the HEPA OU did not change between the 2001 and 2008 Site-Wide ROD, with the exception that ground water cleanup standards were added in the 2008 Site-Wide ROD.

2009

- The revised Compliance Monitoring Plan/Contingency Plan for the final remedies was issued (Dibley et al., 2009b).
- An Engineering Evaluation and Upgrade was initiated at 829-SRC Treatment Facility.

2010

- An Engineering Evaluation and Upgrade was initiated at 815-DSB Treatment Facility.
- An Explanation of Significant Difference (ESD) was submitted to change the treatment of nitrate at the Building 829-Source Treatment Facility (Ferry et al., 2010).

3. Background

3.1. Physical Characteristics

3.1.1. Site Description

LLNL Site 300 is a U.S. DOE experimental test facility operated by the Lawrence Livermore National Security (LLNS), Limited Liability Corporation. It is located in the Eastern Altamont Hills 17 miles east of Livermore, California (Figure 1). At Site 300, DOE conducts research development, and testing associated with high-explosive materials. Historic Site 300 operations involved the release of a number of contaminants to the environment. These releases occurred primarily from spills, leaking pipes, leaching from unlined landfills and pits, high explosive test detonations, and disposal of waste fluids in lagoons and dry wells (sumps). The climate at Site 300 is semi-arid; approximately 10 to 15 inches of precipitation falls each year, mostly in the winter.

The HEPA OU is approximately 934 acres in size, and is located in the southeastern part of Site 300 (Figure 2). This area is characterized by steep, hilly terrain with northwest-southeast trending canyons and ridges. Facilities in the HEPA have been in use since the late 1950s for the chemical formulation, mechanical pressing, and machining of HE compounds into shaped detonation devices. Solid HE waste remaining after machining operations was incinerated at the HE Burn Pit located near Building 829 in the northern part of the HEPA OU. From the mid to late 1950s through 1985, liquid waste generated during machining operations was discharged to unlined disposal lagoons.

In 1984, two double-lined HE surface impoundments were installed south of Building 817 to receive all HE process waste water and replace the unlined disposal lagoons. The surface impoundments allowed dissolved explosives chemicals in the wastewater to degrade from exposure to ultraviolet rays in sunlight. These surface impoundments were closed in 2005 under the oversight of the California Regional Water Quality Control Board (RWQCB).

In 1997, the Final Closure Plan for the HE Burn Pit facility at Building 829 was submitted to the regulatory agencies (Lamarre et al., 1997). This facility consisted of three unlined pits and an open-air burn unit to incinerate HE waste. As specified in the Final Closure Plan, the HE Burn Pit facility was dismantled, capped, and three deep ground water wells (W-829-15, W-829-1938, W-829-22) were installed in the regional Tnbs, aquifer for post-closure monitoring (Figure 3).

Thirteen confirmed chemical release sites (source areas) have been identified in the HEPA OU (Figure 3). These include the ten unlined disposal lagoons (806/807, 807A, 807B, 814, 817, 825, 826, 827C/D, 827E and 828), the former Building 815 drum rack/hard stand, the former Building 810 dry well, and the former 829 Open Burn Pit. The former drum rack/hard stand that was used to store and dispense TCE near Building 815 is considered to be the primary source of VOCs. The unlined HE rinsewater disposal lagoons at Buildings 806, 807, and 817 and the former dry well at Building 810 are considered the primary source areas of HE compounds and perchlorate. As discussed above, the HE Open Burn Pit facility was also a source area for VOCs and perchlorate. There are also multiple natural and anthropogenic sources of nitrate in the ground water. Studies suggest that natural soil and septic discharges are probably a greater source of nitrate than discharge of HE-bearing waste fluids to the former lagoons and dry wells (Madrid et al., 2006).

Six ground water extraction and treatment systems are currently in place and operating to remediate VOCs, nitrate, perchlorate, and HE compounds. To evaluate the progress of remediation, ground water is monitored for these constituents in all monitor, extraction and guard wells. The locations of existing monitor, extraction and water supply wells and treatment facilities are shown on Figure 3.

3.1.2. Hydrogeologic Setting

This section describes the general hydrogeologic setting for the HEPA OU, including the unsaturated zone and the six hydrostratigraphic units (HSUs) underlying the area. A conceptual hydrostratigraphic column for the southeast corner portion of Site 300 including the HEPA is shown on Figure 4. Hydrogeologic cross-sections showing the HSUs and the vertical distribution of total VOCs, RDX, and perchlorate in the HEPA OU are shown on Figures 5, 6, and 7 respectively.

3.1.2.1. Vadose (Unsaturated) Zone

The thickness of the vadose zone in the HEPA varies from less than 20 ft in the Quaternary alluvial sand and gravel (Qal) of the Corral Hollow Creek floodplain to over 350 ft at the higher topographic elevations in the northwestern part of the OU. In some parts of the HEPA, limited amounts of perched ground water occur in the Tertiary Pliocene nonmarine sediments (Tpsg-Tps) and Tertiary Neroly Upper Siltstone/Claystone (Tnsc₂) stratigraphic units within the vadose zone.

3.1.2.2. Saturated Zone

The six HSUs in the HEPA OU are described below.

Qal HSU – The Qal HSU consists of alluvial sands and gravels along with minor silts and clays located along the southern Site 300 border within the floodplain of Corral Hollow Creek. It ranges from 0 to 35 ft in total thickness, but saturated thickness is spatially and temporally variable depending on seasonal rainfall. Ground water in this HSU flows generally to the east. The Qal HSU is recharged by surface runoff from nearby canyons, by direct infiltration during seasonal rainfall events, and from confined ground water in bedrock aquifers that subcrop beneath the Qal. Corral Hollow Creek discharges to the east into the San Joaquin Valley.

Tpsg-Tps HSU – The Tertiary Pliocene sand and gravel (Tpsg-Tps) HSU consists of variably saturated, perched ground water present in Tertiary sand and gravels (Tpgs) and the underlying Tps claystones. Perched ground water is present at depths ranging from ground surface where it discharges at Spring 4 to 45 ft below ground surface (bgs) in the vicinity of Building 815. Ground water in this HSU flows to the southeast.

Tnbs₂ HSU – The Tertiary Neroly Upper Blue Sandstone (Tnbs₂) HSU is saturated beneath the southern part of the HEPA OU from Building 815 to the site boundary. Ground water in the Tnbs₂ HSU occurs under unconfined to confined (including flowing artesian) conditions. Under unstressed conditions, Tnbs₂ ground water levels in the southern part of the HEPA are higher than water levels in the overlying Qal HSU, resulting in an upward hydraulic gradient. However, under stressed (pumping) conditions, this upward hydraulic gradient can be reversed if the potentiometric head elevation in the Tnbs₂ HSU falls below that in the Qal HSU. Under these conditions, ground water from the Qal HSU flows downward into the Tnbs₂ HSU. The saturated thickness of the Tnbs₂ HSU ranges from 0 to 60 ft. Depth to ground water in the Tnbs₂ HSU ranges from 40 to 165 ft bgs. Ground water in this HSU flows to the southeast.

Tnsc_{1b} HSU – Ground water occurs under unconfined to confined conditions in the Tertiary Neroly Lower Siltstone/Claystone (Tnsc_{1b}) HSU beneath the HEPA OU. The Tnsc_{1b} HSU is saturated beneath the southern part of the HEPA with a saturated thickness of approximately 25 ft. Depth to ground water in this HSU ranges from 145 to 250 ft bgs. Ground water flow is to the southeast.

Tnbs₁ HSUs – The Tertiary Neroly Lower Blue Sandstone (Tnbs₁) HSU consists of Neroly Formation sandstone and conglomerate interbedded with siltstone and claystone. These HSUs are present throughout the HEPA OU. Two water-bearing zones are present in the Tnbs₁ stratigraphic unit which are separated by a 10-ft thick claystone (claystone marker bed) that exists throughout the southeast corner of Site 300. Ground water occurs under unconfined to confined (including flowing artesian conditions) in the upper and lower Tnbs₁ HSUs. The saturated thickness of the upper Tnbs₁ HSU ranges from 75 to 125 ft with depths to ground water

ranging from 300 to 400 ft bgs. The saturated thickness of the lower Tnbs₁ HSU is greater than 150 ft with depths to ground water ranging from 400 to 500 ft bgs. Ground water flow is to the southeast.

The lower Tnbs₁ HSU is the currently the main water-supply aquifer for Site 300; however, the site will eventually be transitioning to the Hetch Hetchy water supply. Site 300's water needs are currently supplied by onsite water-supply Well 20, which is located in the southern part of the HEPA OU and is completed in the lower Tnbs₁ HSU. Onsite water-supply Well 18 is located in the same area and serves as a backup water supply. After the transition to Hetch Hetchy water occurs, Well 20 will serve as a backup water supply well and Well 18 will no longer be used.

3.2. Land and Resource Use

Before DOE established Site 300 as a remote testing facility in 1955, the area was used for cattle grazing. Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7,000 acres is developed. There have been no changes in land, building, or ground water use in the HEPA OU since the Site-Wide ROD was signed in 2008 and, other than the changes in onsite water supply uses documented below, none are anticipated.

The HEPA is still used for machining and storage of HE and is accessible only to DOE/LLNL workers.

The HEPA OU extends to the southeastern site boundary. The land adjacent to the OU consists of private rangeland. The nearest major population center (Tracy, California) is 8.5 miles to the northeast. There is no known planned modification or proposed development of the offsite rangeland adjacent to the OU.

At Site 300, ground water is used for a variety of onsite water supply needs including cooling towers, HE processing, dust control and fire suppression. Bottled water is the primary source of onsite drinking water, but potable ground water from onsite water-supply Well 20 is also available. Onsite water-supply Well 20 is completed in the Lower Tnbs₁ bedrock HSU at a depth of 387 to 518 ft bgs. Although several nearby ground water monitor wells that are completed in the shallower Tnbs₂ HSU contain TCE, TCE has not been detected in Well 20 because it is sealed through the shallow aquifer. Well 18, also located in the southeast part of the HEPA OU, is used as a backup water-supply well. Because Well 18 and Well 20 have common piping, LLNL has been pursuing connecting the Site 300 water-supply system to Hetch Hetchy water. Monthly sampling is conducted for both wells, and Well 18 has not had a confirmed detection of VOCs since 2002 when TCE was detected at a concentration of 0.3 µg/L, below both the 5 µg/L MCL and 0.8 µg/L State Public Health Goal. VOCs have been detected in Well 18 at a concentration above the MCLs only once in thirty years of monthly monitoring (in 1986). Therefore, there is no potential for contamination of the potable water-supply system. The locations of Wells 18 and 20 are shown on Figure 3.

Site 300 plans to transition to the Hetch Hetchy water supply in 2012. After this transition occurs, Well 20 will be used as a backup water supply and Well 18 will no longer be used. Onsite water-supply Well 20 is currently pumped on an as-needed basis with intermittent pumping rates ranging from less than 20 to over 60 gallons per minute (gpm). After the transition to Hetchy Hetchy water, the total amount of water removed by Well 20 pumping on an

annual basis is expected to be significantly lower. The lower pumping rates at Well 20 are not expected to impact groundwater flow and contaminant transport in the Tnbs₂ HSU because Well 20 is not completed in this interval. However, there is an offsite water supply well (GALLO1) located within 50 ft of the site boundary of HEPA and intermittent pumping from this well may influence ground water levels in the Tnbs₂ HSU (Figures 3 and 5). According to information provided by the well owner, well GALLO1 is pumped at rate of about 10 gpm for short periods of time. Surface water at Site 300 is not consumed by humans. In the past, former onsite water supply Well 6 was also used at Site 300; however, TCE was detected in this well in 1982 and in 1989, the well was abandoned and replaced with Well 20.

Site 300 has unique environmental qualities, largely because it has not been grazed for over 50 years and contains several habitat types and numerous special status species (e.g., threatened and endangered species, migratory birds, and rare plants). Annual grasslands cover the majority of the HEPA OU, with an isolated patch of blue oak woodland that crosses the southwest boundary of the OU. A wetland associated with Spring 14 also occurs in this area. Spring 5, an area of shallow ground water centrally located within the OU, does not have significant wetland development, as surface water is absent from this location. Special status species found within the HEPA OU include the Big Tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B. The entire OU resides within the upland habitat for the threatened California tiger salamander (*Ambystoma californiense*). The wetland associated with Spring 14 provides breeding habitat for the threatened California red-legged frog (*Rana aurora draytonii*), and the entire OU resides within the upland dispersal habitat for this species. Loggerhead shrikes (*Lanius ludovicianus*), a California Species of Special Concern, have been observed in the HEPA OU, and nesting has also been observed within the OU. A five-year ecological review included in the 2008 Annual Compliance Monitoring Report updated the assessment of the ecological impacts from Site 300 contaminants, and found no impact to ecological receptors from releases within the HEPA OU beyond those originally identified in the baseline ecological risk assessment (see Section 7.5.2), although chloride in Spring 14 was identified as requiring future review. Monitoring for chloride in Spring 14 was conducted and reported in the 2010 Annual Compliance Monitoring Report (CMR). Although the maximum chloride concentration detected in Spring 14 exceeded the maximum concentration observed in background springs, the chloride concentration in the most recent sample collected from Spring 14 was below the maximum concentration detected in the background springs. Chloride concentrations will be monitored in future samples collected from Spring 14. An LLNL ecologist reviewed the HEPA ecological data collected between 2008 and 2011 to evaluate whether any changes in contaminant or ecological conditions were present that could impact ecological receptors. No changes were identified. All activities are reviewed by the LLNL biologist to determine if there would be any impacts to species of special concern. Access to Site 300's unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.3. History of Contamination

Surface spills at the drum storage and dispensing area for the former Building 815 steam plant, where TCE was used to clean pipelines, resulted in the release of TCE to the ground surface. This release site is the main source of TCE in ground water in the HEPA OU. Another minor source of TCE in ground water resulted from leaking contaminated waste stored at the

former Building 829 Waste Accumulation Area. In addition, between 1959 and 1985, waste fluids were discharged to dry well 810A, resulting in the release of VOCs to the subsurface. From the mid-to-late 1950s to 1985, rinsewater containing HE compounds was discharged to nine former unlined rinsewater lagoons. The largest volumes of HE-bearing rinsewater were discharged from Buildings 806, 807, and 817 (Henry, 1981; Crow et al., 1986) to the former rinsewater lagoons. These former rinsewater lagoons are the primary source of HE compounds (mainly RDX) and perchlorate in ground water. Three Resource Conservation and Recovery Act (RCRA)-regulated HE Burn Pits were located in the vicinity of Building 829 in which HE particulates and cuttings, explosive chemicals, and explosives-contaminated debris were burned. Reportedly, nearly 150 kilograms (kg) per month of explosives, reactive chemicals, and explosives-contaminated combustible waste were destroyed in the burn pit. The facility operated from the late 1950s until 1998 when the HE Burn Pit was capped and closed under RCRA. No significant HE Burn Pit contamination has been detected in environmental media.

3.4. Initial Response

DOE/LLNL began environmental investigations in the HEPA OU in the early 1980s to evaluate the sources of contamination detected in former water-supply Well 6 and to determine if wastewater discharges into the unlined disposal lagoons had contaminated ground water. Since then, 194 boreholes have been drilled in the HEPA OU; 95 of these boreholes have been completed as ground water monitoring, injection or extraction wells (Figure 3). The geologic and chemical data from these wells and boreholes were used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminants. Site characterization activities also included analyses of water samples from springs, and passive and active soil vapor surveys.

As summarized in Section 2, remediation activities at the HEPA OU conducted prior to the 2001 Interim Site-Wide ROD included sealing and abandoning former water-supply Well 6, decommissioning of the former rinsewater lagoons and dry wells, closure and capping of the former HE Burn Pit, and extraction and treatment of contaminated ground water.

3.5. Contaminants of Concern

Four types of COCs have been identified in environmental media in the HEPA OU: VOCs, HE compounds, perchlorate, and nitrate. VOCs have been identified as COCs in subsurface soil, ground water, and surface water at Spring 5 (Section 3.5.1). The HE compounds HMX and RDX are COCs in surface soil and subsurface soil/rock, and RDX and 4-Amino-2,6-dinitrotoluene (4-ADNT) are COCs in ground water (Section 3.5.2). Perchlorate and nitrate are COCs only in ground water (Sections 3.5.3 and 3.5.4, respectively). The distribution of COCs in ground water HSUs in the HEPA OU is discussed in Section 3.5.5.

3.5.1. VOCs in Subsurface Soil, Ground Water, and Surface Water

VOCs, primarily TCE, a human carcinogen, are present in subsurface soil and rock, in surface water at Spring 5, and in ground water. The baseline human health risk assessment estimated an excess cancer risk of 5×10^{-6} to onsite workers inhaling VOCs evaporating from subsurface soil into outdoor ambient air in the vicinity of Building 815.

TCE is a COC in HEPA OU ground water and is present at concentrations above the 5 µg/L MCL cleanup standard. While chloroform, 1,1-DCE, cis-1,2-DCE were identified as ground water COCs, their current concentrations are below their respective MCL cleanup standards.

An excess cancer risk of 1×10^{-5} was also estimated for onsite workers inhaling TCE and 1,1-dichloroethylene (DCE) volatilizing from surface water at Spring 5.

Risk mitigation remediation progress is discussed in Section 7.5.2.

The baseline ecological assessment determined that a risk from copper and cadmium existed for aquatic organisms, ground squirrels, and deer. Aquatic organisms are at risk from copper in the shallow, near-surface ground water at Spring 5. The Toxicity Quotient using California Applied Action Levels exceeded 1 for copper in ground water samples from this location. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium in surface soil. The combined oral and inhalation pathway Hazard Quotient exceed 1 for these species, which was driven by the oral pathway. Surveys for the presence of surface water at Spring 5, and algae and micro-invertebrate bioassays conducted to identify the true risk to aquatic organisms found no current adverse impact. Similarly, site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts.

3.5.2. HE Compounds in Surface Soil, Subsurface Soil/Rock, and Ground Water

The HE compounds HMX and RDX are human carcinogens present in surface soil, subsurface soil and rock, and ground water in the HEPA OU. The baseline human health risk assessment calculated an excess cancer risk of 2×10^{-6} for RDX assuming human ingestion of contaminated ground water from a hypothetical well located at the Site 300 boundary. RDX is a COC in HEPA OU ground water and is present at concentrations above the 1 µg/L reporting limit cleanup standard. There was no risk to onsite workers associated with HMX and RDX in surface and subsurface soil under an industrial land use scenario. There is no risk to offsite residents because this soil contamination is wholly contained onsite and there are no pathways through which offsite residents could be exposed. Other HE compounds have also been sporadically detected in ground water in the HEPA OU near the Building 815-Source and Building 817-Source treatment facilities, including nitrobenzene and 4-ADNT. Detections of HE compounds other than HMX and RDX reflect a recent change in the Site 300 sampling plan requested analyses to EPA Method 8330. Previously, only RDX and HMX were analyzed and reported, however, now the full EPA Method 8330 suite of compounds is being analyzed and reported. These compounds are discussed in Section 6.4.1.2.3.

3.5.3. Perchlorate in Ground Water

Perchlorate, while not a carcinogen, interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate may disrupt thyroid functions by decreasing hormone production (U.S. EPA, 2005). There was no human health risk or hazard identified associated with perchlorate in ground water because there is no exposure pathway. However, perchlorate is a COC in HEPA OU ground water and is present at concentrations above the 6 µg/L California State MCL cleanup standard.

3.5.4. Nitrate in Ground Water

Elevated nitrate is present in ground water as a result of releases from a combination of natural and anthropogenic sources in the HEPA OU. In addition to natural soil nitrate and septic

system discharges, HE- and nitrate-bearing wastewater was discharged to the former lagoons and dry wells in the HEPA OU. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. There was no human health risk or hazard identified associated with nitrate in ground water. However, nitrate is a COC in HEPA OU ground water and is present at concentrations above the 45 mg/L MCL cleanup standard.

3.5.5. Distribution of COCs in Ground Water HSUs

Total VOCs, RDX, perchlorate, and elevated nitrate are the main focus of ground water remediation in the HEPA OU and most ground water contamination occurs in the Tnbs₂ HSU. The Tnbs₂ HSU was the main water-supply aquifer for Site 300 before contaminants were detected in it during the mid-1980s. The current Site 300 water-supply well (Well 20) pumps from the deeper and uncontaminated lower Tnbs₁ HSU. In the future, Site 300 will be transitioning to the Hetch Hetchy reservoir as its primary water supply. Local ranchers continue to pump water from offsite wells completed in the Tnbs₂ HSU for domestic use and livestock watering. The offsite water-supply well that is located downgradient from the HEPA OU is GALLO1. Other offsite active water-supply wells located south of Site 300 include CON1, CON2, and CDF1, but these wells are located approximately 2,500 ft to the east of the HEPA OU and cross-gradient from the VOC plume emanating from the HEPA. Because these wells are located outside of the HEPA and would not be impacted by the HEPA VOC plume, these water-supply wells are not discussed further in the HEPA Five-Year Review. These wells are discussed in the GSA Five-Year Review, as they are located downgradient of the GSA OU and VOC plume. Well GALLO2 is located south of the GSA OU and east of the HEPA OU. This well is thought to have been drilled in the 1940s, and is not used as a water-supply well. There is no pump in this well, and it has not been used for many years. No VOCs have ever been detected in this well and because this well is not being pumped, it is not expected to have any future impact on any nearby VOC plumes. Guard wells and offsite water-supply wells are monitored regularly for HEPA COCs.

In the Tnsc_{1b} HSU, ground water contamination has not been detected in most areas. Only a limited volume of perched ground water is contaminated with TCE, perchlorate, and elevated nitrate in the HEPA OU. This perched water is located beneath the former Building 829 HE Burn Pit and Waste Accumulation Area in the northwest part of the HEPA OU. The Tnsc_{1b} HSU also contains contaminants from sources located in the Building 832 Canyon OU upgradient (northeast) of the HEPA OU. The Building 832 Canyon OU is most likely the source of Tnbs₂ HSU contamination located near the W-830-2216 extraction well.

Total VOCs, RDX, perchlorate, and elevated nitrate have also been detected in the sands and gravels of the Tpsg-Tps HSU in the vicinity of Building 815, although wells in this area have recently been dry. Elevated nitrate, perchlorate and total VOCs are also present in the Tpsg-Tps HSU near the Building 817 Proximal treatment facility. No contamination has been detected in the Tps portion of the Tpsg-Tps HSU, or in the upper and lower Tnbs₁ HSUs in the HEPA OU.

3.6. Summary of Basis for Taking Action

Remedial actions were initiated in the HEPA OU to address unacceptable human health risks associated with onsite worker inhalation exposure to VOCs volatilizing from the subsurface soil to outdoor air in the vicinity of Building 815 and surface water at Spring 5. VOCs, perchlorate,

and nitrate are present in HEPA ground water at concentrations exceeding MCL cleanup standards, and RDX is present in ground water at concentrations exceeding its cleanup standard.

4. Remedial Actions

4.1. Remedy Selection

The remedy selected for the HEPA OU is intended to achieve the following Remedial Action Objectives (RAOs):

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.
- Prevent human inhalation of VOCs volatilizing from subsurface soil to air that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4} , or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative hazard index greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

In the 2001 Interim Site-Wide ROD, the remedy for the HEPA OU was selected based on its ability to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the HEPA OU consisted of:

1. Ground water monitoring to evaluate the effectiveness of the remedial action, to determine when cleanup standards are met, and to ensure there is no impact to downgradient water-supply wells.
2. Risk and hazard management to prevent onsite worker exposure to VOCs volatilizing from Spring 5 until risk and hazard is mitigated through active remediation. Institutional/land use controls to prevent human exposure to contamination and to protect

the integrity of the remedy. The institutional/land use controls for the HEPA OU are described in Section 4.4 and Table 2.

3. Extracting and treating VOCs, HE compounds, and perchlorate in ground water to mitigate unacceptable VOC inhalation risk for onsite workers, prevent further impacts to ground water and offsite plume migration, and reduce contaminant concentrations in ground water to cleanup standards.
4. MNA of nitrate in ground water.

4.2. Remedy Implementation

Ground water extraction and treatment systems (GWTS) have been operating in the HEPA OU since 1999. The location of ground water extraction wells and treatment facilities are shown in Figure 3. There are six GWTSs currently operating in the OU:

1. Building 815-Source (815-SRC),
2. Building 815-Proximal (815-PRX),
3. Building 815-Distal Site Boundary (815-DSB),
4. Building 817-Source (817-SRC),
5. Building 817-Proximal (817-PRX), and
6. Building 829-Source (829-SRC).

Since the last HEPA Five-Year Review, formal engineering evaluations and upgrades were conducted at treatment facilities 829-SRC and 815-DSB. This activity includes: (1) a comprehensive assessment and testing of the existing ground water extraction wellfield and treatment system to determine its effectiveness in reducing contaminant concentrations, mass, and plume size, and (2) identifying, designing, and implementing extraction wellfield and/or treatment facility upgrades to ensure reliable and efficient operations and accelerate site cleanup and completion (i.e., replacing aging system components, increasing facility capacity to accommodate flow from additional extraction wells). The treatment facility changes associated with these engineering evaluations and upgrades are discussed in this section.

The 815-SRC GWTS began operation in September 2000, removing VOCs (primarily TCE), HE compounds (RDX and HMX), and perchlorate from ground water. Initially, the system extracted from one extraction well (W-815-02) and consisted of aqueous-phase granular activated carbon (GAC), an ion-exchange system, and an anaerobic bioreactor for nitrate destruction. The treated effluent was discharged to a misting system. The anaerobic bioreactor was decommissioned in 2003. In 2005, the wellfield was expanded to include extraction well W-815-04, with a current combined flow rate of approximately 1.2 gpm. The current GWTS configuration includes a Cuno filter to remove particulates, two ion-exchange resin columns connected in series for perchlorate removal, and three aqueous-phase GAC canisters (also connected in series) for VOC and HE compound removal. In 2005, the discharge method of misting was replaced by injection of the treated effluent into well W-815-1918 for *in situ* denitrification in the Tnbs₂ HSU.

The 815-PRX GWTS began operation in October 2002, removing TCE and perchlorate from ground water. Ground water is extracted from wells W-818-08 and W-818-09 at a current combined flow rate of approximately 2.25 gpm. To increase hydraulic capture in this area, the

combined flow rates for these extraction wells were increased by approximately 0.5 gpm beginning in 2010. The current GWTS configuration includes a Cuno filter to remove particulates, two ion-exchange resin columns connected in series for perchlorate removal, and three aqueous-phase GAC canisters (also connected in series) for TCE removal. In 2005, the discharge method of misting was replaced by injection of the treated effluent into well W-815-2134 where *in situ* natural denitrification converts nitrate to nitrogen in the Tnbs₂ HSU.

The 815-DSB GWTS began operation in September 1999 removing low concentrations (less than 10 µg/L) of TCE from ground water extracted near the Site 300 boundary. Ground water is currently extracted from wells W-35C-04 and W-6ER at a combined flow rate of approximately 3 to 4 gpm. During the review period, an engineering evaluation and upgrade was conducted at the 815-DSB GWTS. Facility upgrades included replacing aging system components (i.e., control system, electronics, and pipelines) and increasing its capacity to accommodate flow from additional extraction wells by installing new treatment media vessels and media. As part of this upgrade, monitor wells W-815-2111 and W-815-2110 and all extraction wells will be outfitted with pressure transducers and added to the treatment facility real-time monitoring system (TFRT). The TFRT system allows ground water elevations to be monitored remotely in real-time via a computer network and is especially useful for monitoring water level changes during hydraulic tests and other stressed conditions. The 815-DSB GWTS originally operated intermittently on solar-power until site power was installed in 2005 which allowed the system to operate 24-hour/day. The current GWTS configuration includes a Cuno filter to remove particulates and three aqueous-phase GAC canisters connected in series for TCE removal. The treated effluent is discharged to an infiltration trench (Figure 3).

The 817-SRC GWTS began operation in September 2003, removing HE compounds (RDX and HMX) and perchlorate from ground water. Well W-817-01 extracts ground water from a very low yield portion of the Tnbs₂ aquifer. It pumps ground water intermittently using solar power at current flow rates ranging from 40 to 160 gallons per month. The current GWTS configuration includes a Cuno filter to remove particulates, two ion-exchange resin columns connected in series for perchlorate removal, and three aqueous-phase GAC canisters (also connected in series) for HE compound removal. Treated ground water is injected into upgradient injection well W-817-06A where *in situ* natural denitrification converts nitrate to nitrogen in the Tnbs₂ HSU.

The 817-PRX GWTS began operation in September 2005, removing VOCs, RDX, and perchlorate from ground water. Initially, ground water was extracted from wells W-817-03 and W-817-04 at a combined flow rate of approximately 1.0 gpm, although the vast majority of ground water was extracted from well W-817-03. Due to the low yield from ground water extraction well W-817-04, extraction from this well was discontinued in December 2007. In 2007, the extraction wellfield was also expanded to include Tpsg-Tps HSU extraction well, W-817-2318. Ground water is currently extracted from W-817-2318 and W-817-03 at a combined flow rate of approximately 1.5 to 2.0 gpm. At 817-PRX, the current GWTS configuration includes a Cuno filter to remove particulates, two aqueous-phase GAC canisters connected in series for TCE and RDX removal, and three ion-exchange resin columns (also connected in series) for perchlorate removal. A third aqueous-phase GAC canister completes the treatment chain, and is placed in this position to remove any residual organic compounds that may be emitted from new ion-exchange resin. Treated ground water containing nitrate is injected into upgradient injection wells W-817-2109 and W-817-02 that was added in 2007. The

treated effluent is split between the two injection wells where *in situ* denitrification reduces the nitrate to nitrogen in the Tnbs₂ HSU.

The 829-SRC GWTS began operation in August 2005, removing VOCs, nitrate, and perchlorate from ground water. The GWTS configuration included two ion-exchange resin columns connected in series for perchlorate removal, three aqueous-phase GAC canisters (also connected in series) for VOC removal, and a biotreatment unit to treat nitrate. An Explanation of Significant Difference (ESD) was approved by the regulatory agencies in 2010. The ESD documented the decision to use ion-exchange treatment media to remove nitrate from ground water, rather than the existing biotreatment unit (BTU) because:

1. The ion-exchange columns are effectively removing the nitrate to meet effluent discharge limits, rendering the BTU unnecessary.
2. The BTU is impractical under the operational conditions at B829-SRC.
3. Elimination of the BTU is expected to increase the overall operational efficiency of the 829-SRC treatment facility, and decrease operation and long-term maintenance efforts.

In 2010-2011, an engineering evaluation and upgrade was conducted at the 829-SRC treatment facility. As part of this upgrade, the treatment train was modified per the ESD to remove the biotreatment unit for the removal of nitrate. Solar power continues to be used to extract ground water from well W-829-06 at a flow rate of approximately 1 to 10 gallons per day (gpd). The current configuration includes two ion-exchange resin columns connected in series for perchlorate and nitrate removal and three aqueous-phase GAC canisters (also connected in series) for VOC removal. Treated effluent is injected into upgradient well W-829-08.

4.3. System Operations/Operation and Maintenance

The HEPA OU ground water extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this review. All required documentation is in place, and treatment system operations and maintenance (O&M) activities are consistent with established procedures and protocols.

O&M procedures are contained in the following documents:

- Health and Safety Plan and Quality Assurance/Quality Control Plan for the O&M of the HEPA Treatment Facilities, contained within the Interim Remedial Design document.
- Operations and Maintenance Manual for Miniature Treatment Units, Ground Water Treatment Units, and Solar Treatment Units, Volume 13 (Martins, 2007).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Integration Work Sheet Safety Procedure #11341: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.
- Integration Work Sheet Safety Procedure #11314: Environmental Restoration Department (ERD) Site 300 Ion Exchange Resin Emplacement.
- Integration Work Sheet Safety Procedure #11313: ERD Site 300 Off-Road Driving Training.

- Integration Work Sheet Safety Procedure #11343: ERD Routine Ground Water Sampling & Water Level Monitoring at Site 300.
- Integration Work Sheet Safety Procedure #14984: ERD Routine Electronic Operations at Site 300.
- Integration Work Sheet Safety Procedure #11339: ERD Site 300 Hydraulic Pump Operation.
- Integration Work Sheet Safety Procedure #11346: Spent Aqueous and Vapor-phase Granular Activated Carbon (GAC) Replacement at Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Lorega, 2009).
- HEPA Substantive Requirements and the Monitoring and Reporting Program issued by the California RWQCB.
- Site-Wide Compliance Monitoring Plan/Contingency Plan for Interim Remedies at LLNL Site 300 until superseded by Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.

Monitoring and optimizing the performance and efficiency of the extraction and treatment systems comprises a large portion of the O&M activities. Specific O&M activities are summarized in the CMRs. Extracted ground water is sampled throughout the treatment process to ensure compliance with discharge requirements. A compliance summary for the HEPA OU is included in the annual and semi-annual CMRs. These reports can be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at <http://www-erd/library>.

During the five-year review period (September 2006 to September 2011), the 815-SRC, 815-PRX, 815-DSB, 817-SRC, and 817-PRX GWTSs operated in compliance with the Substantive Requirements for Wastewater Discharge with the following exceptions:

- March 2007: The daily maximum and monthly median discharge limits for VOCs were exceeded at the 815-PRX due to polyvinyl chloride glue use to repair the facility (see First Semester 2007 CMR).
- April, July, and October 2009: Facility influent samples collected from the 817-SRC GWTS were actually collected from a sample port after the ion-exchange columns (see 2009 Annual CMR).
- January 2010: The compliance monitoring from the 817-PRX GWTS was inadvertently missed.
- July and August 2011: Methylene chloride was detected in the 829-SRC effluent samples due to resin manufacturing processes (see 2011 Annual CMR).

Treatment system parameters such as pressure and flow are routinely recorded to anticipate potential mechanical problems and monitor system performance.

The major O&M activities for the HEPA ground water treatment systems include:

- Maintaining the particulate filters.
- Maintaining the injection wells and infiltration trenches used to discharge treated ground water.

- Protecting the units from freezing in cold weather.
- Replacing and properly disposing of spent GAC and resin.
- Routinely inspecting and maintaining extraction well pumps, pipelines, and flow meters.

The budgeted and actual environmental restoration costs for the HEPA OU are tracked closely and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

4.4. Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site. Types of land use controls include:

- Institutional controls,
- Engineered controls, and
- Physical barriers.

The U.S. EPA (2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.
3. Enforcement and permit tools.
4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as Federal Facility Agreements (FFAs), that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains onsite.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term “land use controls” is used to encompass institutional controls, engineered controls, and physical barriers.

The land use controls and requirements described herein are only applicable to the HEPA OU and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the HEPA OU are described in Table 2 which presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the HEPA OU. Figure 8 shows the specific areas of the HEPA OU where the land use controls have been maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the HEPA OU by objective, and the status of the land use controls are summarized below.

4.4.1. HEPA OU Land Use Control Objectives

Land use control objectives were established for the HEPA in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use controls identified for the HEPA OU include:

1. **Risk Driver** - VOC concentrations exceed cleanup standards in onsite ground water and are detected at concentrations above the reporting limit, but below drinking water MCL cleanup standards in offsite ground water.

Land use control objectives:

- Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.
- Prevent offsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. **Risk Driver** - Potential exposure to VOCs, HMX, and RDX at depth in subsurface soil.

Land use control objective:

- Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

3. **Risk Driver** - The baseline risk assessment identified a risk of 5×10^{-6} for onsite workers from inhalation of VOCs volatilizing from subsurface soil into outdoor air in the vicinity of Building 815.

Land use control objective:

- Prevent onsite site worker inhalation exposure to VOCs in outdoor air in the vicinity of Building 815 until annual risk re-evaluation indicates that the risk is less than 10^{-6} .

4. **Risk Driver** - The baseline risk assessment identified a risk of 1×10^{-5} for onsite workers from inhalation of VOCs volatilizing from Spring 5 into outdoor air.

Land use control objective:

- Prevent onsite site worker inhalation exposure to VOCs in outdoor air in the vicinity of Spring 5 until annual risk re-evaluation indicates that the risk is less than 10^{-6} .

5. Risk Driver - Potential exposure to contaminated environmental media.**Land use control objective:**

- Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. In the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h).

4.4.2. HEPA OU Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for the HEPA that were established and are implemented to address the risk reduction objectives and their current status.

4.4.2.1. Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL has implemented multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the HEPA area until ground water cleanup standards are met. The land use controls include:

- Dig Permit Process.
- Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well before a dig permit is issued.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, there were no proposals brought to the Work Induction Board to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the HE Process Area OU.

4.4.2.2. Prevent Offsite Water-supply Use/consumption of Contaminated Ground Water: Proprietary and Governmental Institutional Controls and Informational Devices

A VOC plume in the Tnbs₂ HSU with concentrations above MCL cleanup standards originating from the HEPA OU extends approximately 100 ft offsite in the vicinity of monitor wells W-35B-04 and -05. Active private offsite water-supply well GALLO1 is located upgradient from the VOC plume. However, an evaluation of ground water elevation data indicate that the pumping of GALLO1 is drawing the VOC plume towards it. Historically, TCE has been sporadically detected at low concentrations (<1 µg/L) above 0.5 µg/L reporting limit but below the 5 µg/L drinking water Maximum Contaminant Level (MCL) cleanup standard in ground water samples in offsite water-supply well GALLO1. LLNL notified the owner of these detections and DOE offered to provide point-of-use treatment at GALLO1. In addition, the primary objective of the 815-DSB GWTS is to prevent offsite VOC plume migration in the Tnbs₂ HSU and offset the GALLO1 pumping. Pumping at 815-DSB has been successful in minimizing offsite migration of TCE and in reducing contamination near offsite water-supply well GALLO1. Since pumping at 815-DSB has increased, the detections in GALLO1 are less common and usually only occur after the 815-DSB treatment facility has been offline. During the first semester 2011, VOC concentrations were below the 0.5 µg/L reporting limit in fourteen routine and duplicate monthly samples collected from offsite water-supply well GALLO1.

DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend to the property owner including a provision in the MOU that formally documents that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1.

4.4.2.3. Control Onsite Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

- Dig Permit Process.
- Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent potential exposure to VOCs, HMX, or RDX at depth in subsurface soil. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

During this five-year review period, there were no proposals brought to the Work Induction Board or as part of the dig permit process conduct excavation activities within areas of contamination in the HE Process Area OU.

4.4.2.4. Prevent Onsite Site Worker Inhalation Exposure to VOCs Outside Building 815

A pre-remediation risk of 5×10^{-6} was calculated for onsite workers from inhalation of VOCs volatilizing from the subsurface soil into outdoor air in the vicinity of Building 815.

This risk has been successfully mitigated since 2004 (prior to this review period) through ground water extraction and treatment, therefore this land use control is no longer needed (See Section 6.4.2, *Risk Mitigation Remediation Progress*).

4.4.2.5. Prevent Onsite Site Worker Inhalation Exposure to VOCs Near Spring 5: Governmental Controls

The land use controls that have been implemented to prevent onsite worker exposure to VOCs volatilizing into outdoor air in the vicinity of Spring 5 until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

- Dig Permit Process.
- Work Induction Board Process.

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes. These processes are described in Section 4.4.2.3, *Control Onsite Excavation Activities: Governmental Institutional Controls*.

There are currently no active facilities located in the vicinity of the Spring 5 and there is no surface water present in the spring. Current activities in the vicinity of the Spring 5 are restricted to semi-annual spring sampling. The time spent sampling is well below the exposure scenario for which the unacceptable exposure risk was calculated, which assumed a worker would spend 8 hours a day, 5 days a week for 25 years working at Spring 5.

DOE will conduct annual risk re-evaluations when water is present in Spring 5 to determine when the inhalation risk has been mitigated. The risk re-evaluation results will be reported in the Annual Site-Wide Compliance Monitoring Reports (See Section 6.4.2, *Risk Mitigation Remediation Progress*).

4.4.2.6. Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under

residential or unrestricted land use, as required in the Site 300 ROD. The land use control and implementation status is described in more detail below.

Proprietary Controls Implementation Status

To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 FFA and Site 300 ROD contain provisions that assure DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR, Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 ROD, and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

4.4.2.7. Other Controls: Physical Barriers

The fences surrounding Site 300, signs, and security forces control and restrict access to Site 300; thereby preventing the inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300 to ensure they are intact. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

4.4.3. Summary of the Status of HEPA Land Use Controls

The review of the land use controls for the HEPA for this five-year review period determined that these controls are effective for preventing exposure to contaminated media, with the exception of controls for the potential installation of water-supply and agricultural water-supply wells in the footprint of the offsite portion of the HEPA VOC plume. As a result, DOE will initiate discussion with the owners of the property on which the offsite portion of the HEPA VOC plume is located to discuss/negotiate a MOU to prevent the installation of water-supply and agricultural water-supply wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, the MOU will provide point-of-use treatment if VOCs are

detected above the cleanup standards in GALLO1. This DOE action item and a schedule for implementation have been included in Section 10 (Recommendations).

DOE will implement, maintain, and enforce the land use controls for the HEPA for as long as necessary to keep the selected remedy protective of human health and the environment.

5. Progress Since Last Review

This section describes the Protectiveness Statement and recommendations and follow-up actions from the 2007 HEPA OU Five-Year Review. It also describes the status of the actions recommended in this previous review.

5.1. Protectiveness Statement from Last Review

The 2007 HEPA OU Five-Year Review indicated that the remedy for the OU was protective of human health and the environment. The Health and Safety Plan and the Contingency Plan are in place, sufficient to control risks, and properly implemented. Ground water extraction and treatment are effectively controlling the migration of contaminants, and reducing contaminant concentrations in the subsurface as needed to meet cleanup standards in the timeframe anticipated at the time of the ROD. Institutional controls are in place to prevent use of contaminated ground water.

No deficiencies in the remedy were identified during the 2007 Five-Year Review.

5.2. Recommendations and Follow-up Actions from the 2007 Five-Year Review

The following recommendations were developed during the Five-Year Review process in 2007:

1. DOE/NNSA recommend implementing monitored natural attenuation as a health-protective, cost effective final remedy for nitrate in ground water.
2. A land use control will be added that prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. This prohibition will be included in the Final Site-Wide ROD scheduled for 2008. The Final Site-Wide ROD will also reference the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document into which this prohibition will be incorporated.
3. The action-specific ARAR change identified in Section 6.2 of the 2007 Five-Year Review, and ARARs related to ground water cleanup, will be included in the Final Site-Wide ROD scheduled for 2008.
4. Once the extraction wellfields in the HEPA OU have operated long enough for capture zones to fully develop, DOE/NNSA will evaluate the extent of capture and the ability of the extraction wellfield to achieve ground water RAOs. This evaluation will be based on ground water elevation contours and concentration trends in extraction, performance monitoring, and guard wells. If data from this evaluation indicate that the existing extraction wellfield will not achieve ground water RAOs, modifications to the wellfield

will be considered. Modifications may include changes to the extraction well pumping strategy and/or installing additional extraction wells.

No other follow-up actions were identified related to the 2007 Five-Year Review.

5.3. Results of Implemented Actions

The status of actions taken in response to the recommendations listed in Section 5.2 are as follows:

1. Monitored natural attenuation was selected as a final remedy for nitrate in ground water in the 2008 Final Site-Wide ROD.
2. A land use control that prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use was included as a requirement in the 2008 Final Site-Wide ROD.
3. The action-specific ARAR change identified in Section 6.2 was the California Code of Regulations, Title 22, Section 67391.1, adopted April 19, 2003. It contains requirements for imposing legal limitations on future site uses and activities through a land use covenant. A land use control that prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use was included as a requirement in the 2008 Final Site-Wide ROD.
4. During this review period, DOE/NNSA evaluated the extent of hydraulic capture and the ability of the existing extraction wellfield to achieve ground water RAOs based on ground water elevation contours and concentration trends in extraction, performance monitoring, and guard wells. Hydraulic capture zones were developed using observed ground water elevations and, where no data are available, an estimation of drawdown based on the Thiem equation for steady-state flow in a confined aquifer. Hydraulic capture in the Tnbs₂ HSU has also been evaluated through modeling studies that are documented in Appendix A of this report. As a result of this analysis, additional extraction well(s) to increase hydraulic capture are recommended as discussed in Sections 6.4.1 and 9.

5.4. Status of Other Prior Issues

There are no other prior issues.

6. Five-Year Review Process

6.1. Notification of Review/Community Involvement

The report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on May 18, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at

<http://www-erd/library/> or the Environmental Community Relations web page at <http://www-envirinfo.llnl.gov>.

The draft, draft final, and final Five-Year Review is also submitted to the community action group, Tri-Valley Communities Against a Radioactive Environment, for review.

6.2. Identification of Five-Year Review Team Members

The Five-Year Review of the HEPA OU at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Anne Helmig, Hydrogeologist, Weiss Associates.
- John Valett, Hydrogeologist, Weiss Associates.

6.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001b).
- Interim Remedial Design for the HEPA Operable Unit at Lawrence Livermore National Laboratory Site 300 (Madrid et al., 2002).
- Five-Year Review Reports for the HEPA Operable Unit Lawrence Livermore National Laboratory Site 300 (Dibley et al., 2007b).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the HEPA OU (Dibley et al., 2007d, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, and 2011c; LLNL 2008).

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through the first semester of calendar year 2011.

6.4. Data Review and Evaluation

A review and evaluation were conducted of data collected during this review period to determine progress in: (1) remediating ground water to meet cleanup standards (Section 6.4.1), and (2) mitigating risk to onsite workers from exposure to VOCs in subsurface soil and surface water (Section 6.4.2.).

6.4.1. Ground Water Remediation Progress

This section is organized into three subsections: mass removal (Section 6.4.1.1), contaminant concentrations, distribution, and remediation (Section 6.4.1.2), and capture zone analysis (Section 6.4.1.3).

6.4.1.1. Mass Removal

Figures 9, 10, and 11 show the cumulative mass of VOCs, RDX, and perchlorate respectively, removed from ground water by treatment facilities in the HEPA OU. The contaminant mass removed by the HEPA OU ground water extraction and treatment facilities since remediation began include:

- The 815-SRC GWTS has removed over 0.12 kg of VOCs, 1.4 kg of RDX, and 250 g of perchlorate from ground water.
- The 815-PRX GWTS has removed over 0.71 kg of VOCs and 150 g of perchlorate from ground water. Total VOC mass removal is greatest at this treatment facility due to the combination of relatively high COC concentrations and extraction wells that can sustain continuous pumping. High explosives compounds such as RDX have not routinely been detected in the 815-PRX extraction wells.
- The 815-DSB GWTS has removed 0.48 kg of VOCs from ground water. Because only very low VOC concentrations are present in ground water at the leading edge of the plume, high mass removal rates are not expected.
- The 817-SRC GWTS has removed over 3.1 g of perchlorate and 0.0052 kg of RDX from ground water. Due to the very low yields in this area, cumulative mass removal rates are small at 817-SRC as compared to the other HEPA treatment facilities. No VOCs have been removed from this facility because the facility is upgradient of this plume.
- The 817-PRX GWTS has removed over 0.12 kg of VOCs, 260 g of perchlorate, and 0.078 kg of RDX from ground water. The 817-PRX treatment facility (Figure 11) has a higher mass removal rate of perchlorate than other HEPA treatment facilities due to continuous extraction from W-817-03 and its location within the perchlorate plume.
- The overall mass removed by the 829-SRC GWTS is small (0.00031 kg VOCs, 0.16 g perchlorate and 1.3 kg nitrate) because this facility has very low extraction well flow rates.

As the selected remedy for nitrate in the HEPA OU is MNA, following treatment to remove VOCs, HE compounds, and perchlorate, nitrate-bearing water is re-injected into the Tnbs₂ HSU where it undergoes *in situ* biotransformation to benign nitrogen gas (N₂) by anaerobic nitrifying bacteria. Therefore, no nitrate mass removal numbers are given for the treatment facilities.

6.4.1.2. Contaminant Concentrations, Distribution, and Remediation

At the HEPA OU, VOCs (mainly TCE, but also including 1,1-DCE, cis-1,2-DCE, and chloroform) are the primary COCs detected in ground water; RDX, HMX, 4-ADNT, perchlorate, and nitrate are secondary COCs. For the purposes of compliance monitoring, ground water COCs were designated as primary or secondary in the Site 300 Compliance Monitoring Plan. Primary COCs are those that generally exhibit: (1) higher migration rates than secondary COCs, (2) larger horizontal and vertical extent of contamination than secondary COCs, and (3) any other contaminant- or area-specific consideration that indicates that a more frequent sampling frequency is appropriate (e.g., a highly toxic contaminant.) Primary COCs are generally monitored more frequently (semi-annually) than secondary COCs (annually).

Most ground water contamination at the HEPA occurs primarily in the Tnbs₂ HSU. Some TCE, RDX, perchlorate, and nitrate have also been detected in the perched ground water of the Tpsg-Tps HSU in the vicinity of Buildings 815 and 817. Minor concentrations of VOCs, perchlorate, and nitrate are also present in perched ground water in Tnsc_{1b} HSU in the 829-SRC area. No contamination has been detected in the Upper and Lower Tnbs₁ HSUs in the HEPA OU. VOC, HE compound, perchlorate, and nitrate concentrations, distribution, and remediation are discussed in Sections 6.4.1.2.1 through 6.4.1.2.4. During the past five years, COCs have not been detected above MCLs in any HEPA OU guard wells (W-815-2110, W-815-2111, W-35B-01, W-35B-02, W-35B-03, W-35B-04, W-35B-05, W-6H, W-6J, W-4C, W-880-01, W-880-02, W-880-03 and W-814-04). However, in the past and during the five-year review period, COCS (primarily TCE) have been detected in guard wells at concentrations above the 0.5 µg/L reporting limit, but below MCLs, on a sporadic basis. Historically, the only VOC other than TCE detected at concentrations above MCLs was vinyl chloride (0.8 µg/L in W-35B-04 in October 2000 and 0.9 µg/L in W-35B-05 in October 2000). The California MCL for vinyl chloride is 0.5 µg/L.

6.4.1.2.1. VOC Concentrations, Distribution, and Remediation

While the majority of the VOCs contamination in HEPA OU ground water is present in the Tnbs₂ HSU, some VOCs are also present in the Tpsg-Tps and Tnsc_{1b} HSUs. Of the VOC COCs, only TCE is currently detected in HEPA ground water at concentrations above its 5 µg/L MCL cleanup standard, with one exception. 1,2-DCA was detected in March 2011 in two wells located near the former 814 lagoon (W-814-01 and -2138) at concentrations of less than or equal to 0.8 µg/L; slightly above the 0.5 µg/L MCL.

As shown in Table 4, VOC-contaminated ground water extracted from the Tpsg-Tps HSU is treated at the 817-PRX GWTS. VOCs are extracted from the Tnbs₂ HSU and treated by the 815-SRC, 815-PRX, 815-DSB, and 817-PRX GWTSs. The 829-SRC GWTS treats VOCs in ground water extracted from the Tnsc_{1b} HSU. No VOCs are treated by the 817-SRC GWTS, as its extraction wellfield is located upgradient of the VOC plume. The distribution and progress of VOC remediation in the Tpsg-Tps, Tnbs₂, and Tnsc_{1b} HSUs are discussed below.

Tpsg-Tps HSU - Concentrations and the distribution of VOCs in the Tpsg-Tps HSU in the second semester of 2010 are presented in Figure 12. This HSU is only periodically saturated and monitor wells completed in this HSU are frequently dry. Limited recharge has led to insufficient water for sampling in some wells completed in the Tps-Tps HSU. As shown in Figure 12,

VOCs (mainly TCE) have been detected in the sands and gravels of the Tpsg-Tps HSU near the 815-SRC, 815-PRX and 817-PRX treatment facilities.

TCE concentrations in the Tpsg-Tps HSU have decreased from a historical maximum of 450 µg/L in 1992 to a maximum of 53 µg/L in the first semester of 2011. Remediation efforts in this HSU have been focused in the area with the highest concentrations located near 817-PRX extraction well W-817-2318. This extraction well removes ground water from the Tpsg-Tps HSU near Spring 5. Although remediation efforts are hampered by limited recharge, low ground water yield and dry conditions, concentrations of VOCs in the Tpsg-Tps HSU continue to decline. Total VOCs have remained below the 0.5 µg/L reporting limit in Tpsg-Tps well W-35C-05, located near the site boundary.

Because low concentrations of VOCs are detected in the Tpsg-Tps HSU ground water upgradient of the Building 815 source area, and the Tpsg-Tps HSU wells in the Building 815 area are frequently dry, DOE/NNSA recommends installing a new monitor well (W-815-2XM1) near 815-SRC to monitor COC concentrations in the deeper portions of the Tpsg-Tps HSU (Figure 12).

Tnbs₂ HSU - The majority of the VOCs contamination in HEPA OU ground water is present in the Tnbs₂ HSU. Total VOC concentrations in Tnbs₂ HSU ground water have decreased from a historic maximum concentration of 110 µg/L in extraction well W-818-08 (May 1992) to a first semester 2011 maximum total VOC concentration of 40 µg/L in the same well. Figure 13 shows the ground water potentiometric surface map for the Tnbs₂ HSU. The general ground water flow direction in this HSU is to the southeast. Concentrations and the distribution of VOCs and hydraulic capture zones for the 815-SRC, 815-PRX, 815-DSB, and 817-PRX GWTSs in the Tnbs₂ HSU in the second semester of 2010 are presented in Figure 14. As shown on Figure 14, the maximum VOC concentration during the second semester of 2010 was 62 µg/L. The first semester hydraulic capture zones are shown on this figure because these capture zones are more representative of extraction wellfield operations during the past five years. VOCs in Tnbs₂ HSU ground water relative to the HEPA GWTSs are discussed below.

The objective of the 815-SRC GWTS is to remediate VOCs in the Building 815 source area. As shown in Figure 15(a), VOC concentrations in 815-SRC extraction wells have decreased from an historical maximum concentration of 31 µg/L to a maximum of 6.8 µg/L in the first semester of 2011, but showed a stabilized trend since extraction started in 2000. This is likely due to VOCs being drawn into the well during pumping. As shown in Figure 14, the highest VOC concentrations in Tnbs₂ HSU ground water in the HEPA OU are detected approximately 500 ft downgradient of Building 815, which is the primary source of VOC contamination in the HEPA OU ground water. Because there are no confirmed VOC release sites in this downgradient area and Building 815 is a known VOC source area, the VOC plume appears to be detached from its source and the VOC source at Building 815 is likely depleted. A comparison of the 2005 and 2010 total VOC concentrations in the Tnbs₂ HSU (Figure 16) shows a small increase in the extent of contamination north of W-815-04 due to the injection of ground water into W-815-1918. Since remediation began, the 815-SRC GWTS has removed over 0.12 kg of VOCs from ground water.

The 815-PRX GWTS was installed to offset pumping at the 815-DSB GWTS and capture total VOCs from upgradient sources. As shown on Figure 17(a), VOC concentrations in the 815-PRX extraction wells have decreased from a maximum historical concentration of 110 µg/L

(W-818-08, May 1992) to first semester 2011 concentration of 40 µg/L in the same well (April 2011). VOC concentrations in the 815-PRX extraction wells have stabilized in recent years as the wells continue to capture contaminated ground water from upgradient (Figure 14). Extraction wells W-818-08 and W-818-09 display the “NS” for No Sample on Figure 14 because the facility was undergoing major maintenance during the second semester 2010 sampling event. As shown on Figure 14, TCE is the only VOC currently present in these extraction wells. A comparison of the distribution of VOCs in the second semester 2005 versus the second semester 2010 (Figure 16) shows little difference in the extent of contamination near the 815-PRX extraction wells; however, the area of highest concentrations north of extraction wells W-818-08 and W-818-09 have increased as the VOC plume moves downgradient towards these extraction wells. Based on Figure 16 and declining concentration trends in nearby monitor well W-814-02, total VOC concentrations have decreased near 815-PRX injection well W-814-2134 as the total VOC plume continues to be cleaned up and to move downgradient. Since remediation began, the 815-PRX GWTS has removed over 0.71 kg of VOCs from ground water.

The primary objective of the 815-DSB GWTS is to prevent offsite VOC plume migration in the Tnbs₂ HSU, therefore, the most indicative measure of progress is concentration trends in downgradient guard wells. In the early years of operation, VOCs were sporadically detected at a maximum concentration of 1.5 µg/L in guard wells W-35B-02, W-35B-03, W-35B-04 and W-35B-05. As a result, the extraction well flow rate was increased and an additional extraction well was added to the wellfield to increase hydraulic capture. In addition, the facility was converted from solar power to site power to ensure continuous operation. Since these modifications, VOCs have been infrequently detected at low concentrations (<1 µg/L) in guard well W-35B-04, but only after the facility has been offline for repairs. Because the 815-DSB GWTS is located at the leading edge of the VOC plume, its extraction wells capture upgradient TCE-contaminated ground water. This phenomenon is shown by time-series plots of VOC concentrations in the 815-DSB extraction wells, which show increasing TCE concentrations over time (Figure 18). Pumping at 815-DSB has been successful in minimizing offsite migration of TCE and in reducing contamination near offsite water-supply well GALLO1. However some of the increase in TCE exhibited near the 815-DSB treatment facility is probably due to TCE migrating from sources located in Building 832 Canyon. As of the first semester 2011, the 815-DSB GWTS has removed 0.48 kg of VOCs from ground water (Figure 9). Because only very low VOC concentrations are present in ground water at the leading edge of the plume, high mass removal rates are not expected. Tnbs₂ guard wells W-815-2110 and W-815-2111 were installed in 2005 to monitor pumping at offsite water-supply well GALLO1. Because offsite pumping tends to pull VOCs towards GALLO1, VOCs are commonly detected in guard wells W-815-2110 and W-815-2111 at concentrations of less than 3 µg/L. Historically, low concentrations of TCE (< 1 µg/L) have sporadically been detected in GALLO1; however, since pumping at 815-DSB has increased, these detections are less common and usually only occur after the 815-DSB treatment facility has been offline. During the first semester 2011, VOC concentrations were below the 0.5 µg/L reporting limit in fourteen routine and duplicate monthly samples collected from offsite water-supply well GALLO1.

No VOCs are treated by the 817-SRC GWTS, as its extraction wellfield is located upgradient of the VOC plume.

The 817-PRX GWTS was installed to offset pumping at the 815-DSB GWTS and capture total VOCs from upgradient sources. As shown on Figure 19(a), VOC concentrations in the

817-PRX extraction wells have decreased from a maximum historical concentration of 36 $\mu\text{g/L}$ (W-817-03, April 1989) to first semester 2011 concentration of 11 $\mu\text{g/L}$ (W-817-04, March 2011). Concentrations in all extraction wells display an initial decline followed by a period of relatively stable values as contaminants continue to be captured by the extraction wells. Tnbs_2 HSU ground water was initially extracted from wells W-817-03 and W-817-04; however, W-817-04 was converted to a monitor well in late 2007 due to low yields. In 2010, a new well, W-817-2609, was installed south of W-817-03. The well was initially considered to be an extraction well candidate. However, preliminary hydraulic tests showed that this monitor well has low yields, and as a result, W-817-2609 will remain a monitor well. To increase hydraulic capture near the 817-PRX treatment facility, flow rates were recently increased at extraction well W-817-03 for a total combined flow of 2.5 gpm. This flow rate is currently constrained by the maximum injection capacity of the two 817-PRX injection wells. Mass removal performance will be monitored at 817-PRX to determine whether additional facility upgrades (e.g., increased injection well capacity) are warranted to enable increased pumping from well W-817-03. As shown on Figure 16, the 817-PRX treatment facility has not yet had a significant impact on the lateral extent of total VOCs plume in the Tnbs_2 HSU. Since remediation began, the 817-PRX GWTS has removed over 0.12 kg of VOCs from ground water (Figure 9).

Figure 16 compares the existing extraction wells and the distribution of total VOCs in ground water in the Tnbs_2 HSU in the second semester 2005 versus second semester 2010. Overall, the extent of VOC contamination in Tnbs_2 ground water has not changed significantly except near the southern end of 832 Canyon where the spatial distribution of total VOCs appears to have increased due to the presence of an additional contouring location, extraction well W-830-2216. Nevertheless, the area of highest concentrations north of 815-PRX has expanded as the plume moves towards extraction wells W-818-08 and W-818-09. Although the lateral extent of the VOC plumes in the HEPA did not decrease significantly, the total VOC concentrations within the plumes generally continue to decline.

Tnsc_{1b} HSU - One objective of the 829-SRC extraction and treatment system is to reduce VOC concentrations in Tnsc_{1b} HSU ground water (Figure 20). As shown on Figure 21(a), VOC concentrations in ground water collected from 829-SRC extraction well W-829-06 (Tnsc_{1b} HSU) have decreased from a historic maximum of 1,013 $\mu\text{g/L}$ (August 1993) to a first semester 2011 maximum total VOC concentration of 8.1 $\mu\text{g/L}$ (March). To help flush contaminants from this shallow perched water zone, ground water is extracted from well W-829-06, treated, and injected into well W-829-08. Because this facility has very low extraction well flow rates, the overall mass removal is small (0.00031 kg VOCs). The facility was offline during 2009 for an engineering evaluation and upgrade that resulted in a change in the treatment train for nitrate removal (Ferry et al., 2010).

6.4.1.2.2. HE Compound Concentrations, Distribution, and Remediation

HE compounds are detected primarily in the Tnbs_2 HSU in the HEPA (Figure 22). While RDX has historically been detected in Tpsg-Tps HSU ground water, it is not currently detected in this HSU. No HE compounds have been detected in Tnsc_{1b} HSU ground water.

As shown in Table 4, HE-contaminated ground water extracted from the Tnbs_2 HSU is treated at the 815-SRC, 817-SRC, and 817-PRX GWTS. No HE compounds are treated by the 815-PRX, 815-DSB, or 829-SRC facilities as their extraction wellfields are outside the extent of

the RDX plume. The distribution and progress of HE compound remediation in the Tpsg-Tps and Tnbs₂, HSUs are discussed below.

Tpsg-Tps HSU – During the first semester 2011, RDX was not detected at concentrations above the 1 µg/L reporting limit in any ground water samples collected from the Tpsg-Tps HSU. However, this HSU is only periodically saturated and monitor wells completed in this HSU are frequently dry. The historic maximum RDX concentration detected in ground water collected from the Tpsg-Tps HSU was 350 µg/L (March 1988) from well W-815-01; this well has been dry since 1999. More recently, RDX was detected in ground water collected from monitor well W-815-03 at a concentration of 100 µg/L (April 2003).

Tnbs₂ HSU - The 815-SRC GWTS treats RDX in ground water that has migrated to this area from the rinsewater lagoon sources at Buildings 806 and 807. As shown on Figure 15(b), RDX concentrations in groundwater in the 815-SRC extraction wells have decreased from a historical maximum concentration of 170 µg/L in extraction well W-815-04 to a February 2011 concentration of 9.2 µg/L. RDX concentrations in ground water collected from extraction well W-815-02 remain above 50 µg/L due in part to the tendency for RDX to sorb to the media rather than be transported in a dissolved phase. Both extraction wells showed a significant decrease in RDX concentrations following the start of ground water extraction and treatment in 2000. Figure 23 compares the distribution of RDX in the Tnbs₂ HSU in the second semester of 2005 versus the second semester of 2010. The lateral extent of RDX contamination in the Tnbs₂ HSU has not changed significantly during the past five years; however, concentrations in monitor well W-809-03 have increased due to the injection of groundwater into nearby well W-815-1918. As shown on Figure 23, an area of higher magnitude concentrations is also visible near well W-815-1918 as a result of injection into this well. As shown on the time series plot of cumulative mass removed (Figure 10), the 815-SRC treatment facility accounts for most of the RDX removed in the HEPA due to the high concentrations present and the tendency for RDX to sorb onto the media. Since remediation began, the 815-SRC GWTS has removed over 1.4 kg of RDX from ground water. HMX was detected during the first semester 2011 in several ground water samples collected from 815-SRC wells, including extraction wells W-815-02 and W-815-04 (Figure 15c).

In March 2011, RDX was detected for the first time at a low concentration (2 µg/L) in 815-PRX extraction well W-818-09. No HE compounds were found in nearby extraction well W-818-08. In the future, monitoring for HE compounds will continue in these extraction wells and the frequency of sampling may be increased if detections in ground water continue.

The maximum historic RDX concentration detected in Tnbs₂ HSU groundwater was 204 µg/L measured in 1992 in 817-PRX extraction well W-817-01. As shown in Figure 24(a), RDX concentrations in extraction well W-817-01 have decreased from the 204 µg/L 1992 historical maximum to a concentration of less than 50 µg/L in the first semester of 2011. In recent years, RDX concentrations have been relatively stable as the extraction well continues to pull in contaminated ground water from upgradient (Figure 24[a]). Decreasing maximum RDX concentrations have generally been observed in Tnbs₂ HSU near both the Building 815 and 817 source areas. HE compounds are relatively immobile and due to remediation efforts, the extent of RDX contamination at the leading edge of the Tnbs₂ HSU plume (east of 817-PRX) has remained relatively stable. During the first semester 2011, RDX was not detected at concentrations above the 1 µg/L reporting limit in any samples collected from Tnbs₂ HSU guard wells. HMX is also detected in Tnbs₂ HSU ground water in the 817-PRX area. HMX

concentrations have decreased from a historic maximum of 57 µg/L (1995) in the 817-PRX extraction well W-817-01 to a maximum of 17 µg/L in the first semester 2011 in the same well (Figure 24b).

Since remediation began, the 817-SRC GWTS has removed 0.0052 kg of RDX from ground water. Due to the very low yields in this area, cumulative mass removal rates are small at 817-SRC as compared to the other HEPA treatment facilities.

The HE compound 4-ADNT has been detected sporadically in Tnbs₂ HSU ground water. The highest historic concentration of 4-ADNT detected in HEPA was 24 µg/L, measured in the 817-SRC extraction well W-817-01 in September 1997. 4-ADNT was also detected at a concentration of 7.5 µg/L in an influent sample to the 815-SRC GWTS in July 2008. During the first semester 2011, 4-ADNT was detected above the 2 µg/L reporting limit in two Tnbs₂ wells at concentrations of 9.3 µg/L in W-809-03 and 2.4 µg/L in W-818-11. During the first semester 2011, 4-ADNT has never been detected above the 2 µg/L reporting limit any Tpsg-Tps or Tnsc_{1b} HSU wells.

In April 2008, nitrobenzene was detected for the first time in the HEPA Tnbs₂ ground water in a sample from the 817-SRC extraction well W-817-01 at a concentration of 6.2 µg/L, and in a sample collected from the influent to the 815-SRC GWTS at a concentration of 4.1 µg/L. Nitrobenzene was not detected above its reporting limit in subsequent samples collected from W-817-01 and the influent to 815-SRC GWTS. During the first semester 2011, nitrobenzene was not detected above the 2 µg/L reporting limit in any HEPA ground water samples.

6.4.1.2.3. Perchlorate Concentrations, Distribution, and Remediation

Perchlorate is detected in the Tpsg-Tps, Tnbs₂, and Tnsc_{1b} HSU in the HEPA (Figures 25 and 27). Most perchlorate contamination at the HEPA occurs primarily in the Tnbs₂ HSU. Perchlorate has also been detected in the perched ground water of the Tpsg-Tps HSU in the vicinity of Buildings 815 and 817. Minor concentrations of perchlorate are also present in Tnsc_{1b} HSU ground water in the 829-SRC area.

Tpsg-Tps HSU - As shown in Figure 25, perchlorate is detected in the Tpsg-Tps HSU ground water at a concentration exceeding the 6 µg/L MCL cleanup standard in only one well in the HEPA. During the first semester 2011, the maximum perchlorate concentration detected in Tpsg-Tps HSU ground water was 14 µg/L in 817-PRX extraction well W-817-2318. The historic maximum perchlorate concentration detected was 17 µg/L (2008) in the same well. Ground water from this well is extracted and treated at the 817-PRX GWTS to remove perchlorate.

Tnbs₂ HSU - As shown on Figure 26 significant progress has been made in cleaning up perchlorate in the Tnbs₂ HSU during the past five years. This figure compares the existing extraction wells and the distribution of perchlorate in ground water in the Tnbs₂ HSU in the second semester 2004 and the second semester 2010. Perchlorate data from the second semester of 2004 was used rather than 2005 as the 2004 data is more representative of the historical perchlorate distribution. Perchlorate concentrations have decreased in Tnbs₂ ground water from a historic maximum of 50 µg/L (W-817-01, February 1998) to a first semester 2011 maximum concentration of 29 µg/L in the same well.

As shown on Figure 15(d), perchlorate concentrations have decreased in both 815-SRC extraction wells, and perchlorate concentrations in W-815-04 are now below the 4 µg/L detection limit. Perchlorate concentrations near 815-SRC began to decline after the installation

of an upgradient injection well W-815-1918. Overall, perchlorate concentrations in the 815-SRC extraction wells decreased from a historical maximum concentration in ground water of 24 $\mu\text{g/L}$ in extraction well W-815-02 to a first semester 2011 maximum concentration of 8.1 $\mu\text{g/L}$ in the same well. Since remediation began, the 815-SRC GWTS has removed over 250 g of perchlorate from ground water.

While perchlorate concentrations in 815-PRX extraction wells (Figure 24[b]) have been stable with concentrations remaining in the range of 6 to 10 $\mu\text{g/L}$, the area with the highest perchlorate concentrations has decreased significantly in the Tnbs₂ HSU (Figure 27). Perchlorate has not been detected in downgradient monitor wells, indicating that the 815-PRX extraction wells are adequately capturing the perchlorate plume in this area and preventing migration toward the site boundary. Since remediation began, the 815-PRX GWTS has removed over 150 g of perchlorate from ground water.

No perchlorate is treated by the 815-DSB GWTS, as its extraction wellfield is located downgradient of the perchlorate plume.

As shown in Figure 24(c), perchlorate concentrations in 817-SRC extraction well W-817-01 have decreased from a historical maximum of 50 $\mu\text{g/L}$ in 1998 to a concentration of less than 29 $\mu\text{g/L}$ in the first semester of 2011. More recently, perchlorate concentrations have been relatively stable as the extraction well continues to pull in contaminated ground water from upgradient (Figure 27). As shown on Figure 27, extraction well W-817-01 has helped reduce the overall extent of the perchlorate plume in this area. Since remediation began, the 817-SRC GWTS has removed 3.1 g of perchlorate from ground water. DOE/NNSA recommend installing a new monitor well W-817-2XM1 (Figure 24) in the Tnbs₂ HSU between the 817-SRC injection and extraction wells to assess the effectiveness of the 817-SRC recirculation cell between extraction well W-817-01 and effluent injection well W-817-06A.

As shown in Figure 19(c), the concentrations of perchlorate in the 817-PRX extraction wells display an initial decline followed by a period of relatively stable values as contaminants continue to be pulled in by the extraction wells. As discussed in Section 6.4.1.2.1, flow rates were recently increased at 817-PRX extraction well W-817-03. Mass removal performance will be monitored at 817-PRX to determine whether additional facility upgrades (e.g., injection well capacity) are warranted to enable increased pumping from well W-817-03. Since remediation began, the 817-PRX GWTS has removed 260 g of perchlorate from ground water. The 817-PRX treatment facility has a higher mass removal rate of perchlorate than other HEPA treatment facilities due to continuous extraction from W-817-03 and its location within the perchlorate plume. As shown on Figure 27, the 817-PRX treatment facility has helped to decrease the extent of the perchlorate plume in the Tnbs₂ HSU.

Overall, perchlorate concentrations continue to decline and the southwestern plume front has been receding due to continued 817-PRX and 817-SRC operations. To the north, the Tnbs₂ HSU perchlorate plume has been declining based on concentration trends observed in monitor well W-809-03 and in 815-SRC extraction wells W-815-02 and W-815-04. Previously, an increasing trend was observed in this area as a result of the mobilization of perchlorate by injection of treated ground water into nearby 815-SRC injection well W-815-1918. Perchlorate was not detected in any of the Tnbs₂ HSU guard wells during the first semester 2011.

Tnsc_{1b} HSU - Perchlorate concentrations in 829-SRC Tnsc_{1b} HSU extraction well W-829-06 have decreased from a historic maximum of 29 $\mu\text{g/L}$ (December 2000) to a concentration of

7.2 µg/L in the first semester 2011; slightly above the 6 µg/L cleanup standard. Perchlorate was not detected at concentrations above its 4 µg/L reporting limit in the most recent samples collected from Tnsc_{1b} HSU monitor wells W-829-08 and W-829-1940.

6.4.1.2.4. Nitrate Concentrations, Distribution, and Remediation

The remedy selected for nitrate in HEPA ground water was monitored natural attenuation based on a study conducted by DOE/NNSA. The study results indicated that denitrification processes are naturally attenuating nitrate in the confined, oxygen-depleted region of the Tnbs₂ HSU in the HEPA OU as discussed below:

- Both nitrate and dissolved oxygen concentrations in ground water decrease significantly as ground water flows from unconfined to confined conditions in the Tnbs₂ HSU.
- Low dissolved oxygen concentrations in the downgradient, confined region of the Tnbs₂ HSU are conducive for anaerobic bacteria to metabolize nitrate, converting it to harmless N₂ gas.
- Stable isotope signatures (i.e., δ¹⁵N and δ¹⁸O) of nitrate in ground water indicate a trend of isotopic enrichment that is characteristic of denitrification.
- Dissolved nitrogen gas concentrations, the product of denitrification, are highly elevated in nitrate-depleted ground water in the confined region of the Tnbs₂ HSU (Beller et al., 2004).

Figures 28 and 29 show the distribution of nitrate in ground water collected in the Tpsg-Tps HSU and the Tnbs₂ HSU, respectively, during the first semester 2010.

As shown in Figure 28, the maximum nitrate concentration detected in ground water in the Tpsg-Tps HSU during the first semester 2011 was 550 mg/L (W-6CS, February). Because there are no known septic systems or other Site 300 operations representing potential nitrate sources near this well, these elevated nitrate levels are probably related to a pre-Site 300 sheep ranch that was discovered in a historic photo of the area. Ground water sampled from all other wells completed in the Tpsg-Tps HSU had significantly lower nitrate concentrations. The highest nitrate concentration found in other wells completed in this HSU was 160 mg/L (817-PRX extraction well W-817-2318, April 2011). Nitrate-bearing ground water extracted from 817-PRX extraction well W-817-2318 is re-injected, following treatment to remove VOCs and perchlorate, into the Tnbs₂ HSU where the nitrate will naturally attenuate. The Tpsg-Tps HSU is variably saturated with primarily seasonal, discontinuous lenses of perched ground water of limited extent. As a result, when ground water is present in this HSU, nitrate will be limited to the extent of saturation in this HSU. Nitrate concentrations in Tpsg-Tps HSU wells located near the site boundary (W-35C-01, W-35C-05, and W-4AS) have been low (<0.5 to 1.8 mg/L) throughout their sampling history.

In the Tnbs₂ HSU, nitrate concentrations typically ranging from 70 to 100 mg/L have been reported in upgradient wells completed in the unconfined portions of the HSU and lower and constant nitrate concentrations typically ranging from less than 0.1 to 3 mg/L have been observed in the downgradient, confined portions of the HSU. This pattern suggests that a balance exists between the rates of nitrate loading in the upgradient, unconfined region of the Tnbs₂ HSU and the rates of nitrate removal by denitrification in the downgradient, confined region of the HSU. Anaerobic bacteria present in the oxygen-depleted, confined region of the Tnbs₂ HSU provides the main mechanism for denitrification. Due to microbial denitrification,

nitrate concentrations remain below the 45 mg/L cleanup standard in all wells near the southern site boundary where the ground water exists under confined conditions.

Nitrate concentrations in HEPA ground water continue to support the interpretation that nitrate is being degraded *in situ* by natural processes. Natural attenuation is demonstrated through multiple independent data sets: (1) oxygen-depleted, nitrate-reducing geochemical conditions, (2) isotopic enrichment in nitrogen-15, (3) excess dissolved nitrogen gas in ground water with low to non-detectable nitrate concentrations, and (4) reduced nitrate concentrations in the oxygen-depleted, confined region of the Tnbs₂ HSU.

The distributions of nitrate in ground water in the HEPA support the presence of the elements important for an MNA remedy: (1) the contamination does not pose an unacceptable risk, (2) nitrate concentrations remain below the 45 mg/L cleanup standard in all wells near the southern site boundary where onsite and offsite water-supply wells are located, and (3) nitrate concentration contours are stable.

6.4.1.3. Capture Zone Analysis

Hydraulic capture of HEPA ground water COCs by the 815-SRC, 815-PRX, 815-DSB, 817-SRC, and 817-PRX extraction wellfields was evaluated to determine the effectiveness of the extraction wells, and if adjustments to well operations (i.e., pumping rates) and/or wellfield expansions could improve remediation effectiveness. Capture zone analysis results are discussed by GWTS areas in Sections 6.4.1.3.1 through 6.4.1.3.5. DOE/NNSA recommendations for wellfield optimization are presented in Section 6.4.1.3.6.

6.4.1.3.1. Capture Zone Analysis at 815-SRC

Contaminant mass removal in 815-SRC area is limited due to low extraction well yields. As a result, DOE/NNSA began reinjecting treated effluent upgradient to increase the hydraulic gradient and flush contaminants toward the extraction wells.

Figure 30 displays the zones of hydraulic capture and injection influence as estimated using the Thiem equation for steady-state radial flow to a well and pumping rates during the first semester 2010. The capture zones are a conservative estimate of hydraulic capture and are representative of operations during the past five years.

To increase hydraulic capture in areas with high RDX and perchlorate concentrations between the 815-SRC and 817-SRC treatment facilities, DOE/NNSA recommends installing a new extraction well west of W-815-02. The new extraction well would be connected to the 815-SRC GWTS for VOC, RDX, and perchlorate removal. The location of this proposed well (W-815-2803) is shown on Figure 30.

Future estimates of ground water capture by the 815-SRC extraction wellfield, including proposed new extraction well W-815-2803, are presented in Figure 14. The Figure 30 capture zones show the extent of hydraulic capture after 5 years of pumping the “As Designed” extraction wellfield as predicted using a FEFLOW model (Appendix A). The “As Designed” extraction wellfield includes pumping from all twelve HEPA extraction wells including the existing 815-SRC extraction wells W-815-02 and W-815-04 and proposed new extraction well W-815-2803. As presented on Figure 30, the addition of proposed extraction well W-815-2803 increases hydraulic capture of VOCs, RDX and perchlorate near 815-SRC. After the new 815-SRC extraction well is installed and connected, hydraulic capture in the Tnbs₂ HSU will be re-evaluated.

6.4.1.3.2. Capture Zone Analysis at 815-PRX

Contaminant mass removal in the 815-PRX area has generally been effective in removing VOCs and perchlorate. Figure 30 displays the zones of hydraulic capture for the 815-PRX extraction wells W-818-08 and W-818-09 and influence of the injection well W-814-2134 as estimated using the Thiem equation for steady-state radial flow to a well and average pumping rates during the first semester 2010. The capture zones presented in Figure 10 are a conservative estimate of hydraulic capture. They are smaller than is typical for the 815-PRX extraction wellfield because these wells were offline during part of the 2nd semester 2010 (on which the data presented in Figure 30 is based) resulting in a lower average yield. In 2010, pumping rates from extraction wells W-818-08 and W-818-09 were increased to expand the hydraulic capture of VOCs and perchlorate in this area.

Future estimates of ground water capture by the 815-PRX extraction wellfield are presented in Figure 30. The Figure 30 capture zones show the extent of hydraulic capture after 5 years of pumping the “As Designed” extraction wellfield as predicted using a FEFLOW model (Appendix A). The “As Designed” extraction wellfield includes pumping from all twelve HEPA extraction wells including increased flow rates at the 815-PRX extraction wells W-818-08 and W-818-09.

6.4.1.3.3. Capture-Zone Analysis at 815-DSB

Figure 30 displays the zones of hydraulic capture and injection influence in the Tnbs₂ HSU as estimated using the Thiem equation for steady-state radial flow to a well and pumping rates during the first semester 2010. The capture zones are a conservative estimate of hydraulic capture and are representative of operations during the past five years.

To increase hydraulic capture of VOCs at the site boundary and further prevent offsite plume migration, flow rates have been increased recently in extraction wells W-35C-04 and W-6ER. In addition, DOE/NNSA recommends converting monitor well W-815-2608 to an extraction well and connecting it to the 815-DSB facility. Monitor W-815-2608, is a low flow well, which is expected to be pumped at a rate of 0.5 gpm. DOE/NNSA also recommends evaluating monitor well W-815-2621 to determine the feasibility of converting this well to an extraction well. Monitor well W-815-2621 is expected to a high flow well, which would be pumped at an extraction rate of 5 gpm, if connected. The location of wells W-815-2608 and W-815-2621 are shown on Figure 30. The 815-DSB extraction wellfield expansion is currently scheduled to be completed in 2013.

The addition of new extraction well W-815-2608 and possibly W-815-2621, together with the increased flow rates at existing extraction wells W-35C-04 and W-6ER are expected to increase hydraulic capture near the site boundary, while avoiding pulling contaminants downgradient. Increased pumping from the 815-DSB extraction wellfield will also help to offset the impact of intermittent pumping at offsite water-supply well GALLO1.

Future estimates of ground water capture by the 815-DSB extraction wellfield are presented in Figure 30. The Figure 30 capture plots show the extent of hydraulic capture after 5 years of pumping the “As Designed” extraction wellfield as predicted using a FEFLOW model. The “As Designed” extraction wellfield includes pumping from all twelve HEPA extraction wells including the existing 815-DSB extraction wells W-35C-04 and W-6ER, and the recommended new extraction well W-815-2608 (and potential new extraction well W-815-2621). A detailed

description of the “As Designed” wellfield and associated pumping rates are described in Appendix A: Groundwater Flow and Contaminant Transport Modeling in the Tnbs₂ HSU.

The extent of capture by the 815-DSB extraction wellfield is expected to change significantly after the extraction wellfield is expanded and new extraction well W-815-2608 (and possibly W-815-2621) is operating. Hydraulic capture in the Tnbs₂ HSU will continue to be evaluated over the next five years and documented in the Annual Compliance Monitoring Reports. Based on this data, DOE/NNSA will pursue opportunities to optimize 815-DSB extraction wellfield operations to maximize contaminant removal as they are identified. However, the pumping strategy for the ground water extraction wells at the site boundary must continue to balance pumping at 815-DSB with pumping at other upgradient areas. Over-pumping of ground water from wells at the site boundary could result in more rapid migration of upgradient contamination towards the site boundary and could lengthen cleanup times for this area.

6.4.1.3.4. Capture Zone Analysis at 817-SRC

Contaminant mass removal in the 817-SRC area has generally been effective in removing RDX and perchlorate. But hydraulic capture has been limited in this area due to low extraction well yields. Figure 30 displays the zones of hydraulic capture and injection influence as estimated using the Thiem equation for steady-state radial flow to a well and average pumping rates during the first semester 2010. The capture zones presented in Figure 30 are a conservative estimate of hydraulic capture and are typical of 817-SRC operations during the past five years.

Future estimates of ground water capture by the 817-SRC extraction wellfield are presented in Figure 30. The Figure 30 capture zones show the extent of hydraulic capture after 5 years of pumping the “As Designed” extraction wellfield as predicted using a FEFLOW model (Appendix A). The “As Designed” extraction wellfield includes pumping from all twelve HEPA extraction wells including pumping from the 817-SRC extraction well W-817-01 and the recommended new 815-SRC extraction well W-815-2803 (discussed in Section 6.4.1.2). This extraction well will increase hydraulic capture between the 815-SRC and 817-SRC treatment facilities.

6.4.1.3.5. Capture Zone Analysis at 817-PRX

Contaminant mass removal in the 817-PRX area has generally been effective in removing VOCs, RDX and perchlorate. An additional well, W-817-2609, was installed in 2010 to increase hydraulic capture; however, the well will remain a monitor well due to low yields. Figure 30 displays the zones of hydraulic capture and injection influence as estimated using the Thiem equation for steady-state radial flow to a well and average pumping rates during the first semester 2010. The capture zones presented in Figure 30 are a conservative estimate of hydraulic capture and are typical of 817-PRX operations during the past five years.

Future estimates of ground water capture by the 817-SRC extraction wellfield are presented in Figure 30. The Figure 30 capture zones show the extent of hydraulic capture after 5 years of pumping the “As Designed” extraction wellfield as predicted using a FEFLOW model (Appendix A). The “As Designed” extraction wellfield includes pumping from all twelve HEPA extraction wells including increased pumping from 817-PRX extraction well W-817-03. This extraction well has additional flow rate capacity; however, higher flow rates are limited by the discharge capacity of the two 817-PRX injection wells.

6.4.1.3.6. Wellfield Optimization Recommendations

Based on the capture zone analysis for the HEPA facilities, DOE/NNSA recommends:

1. Installing a new extraction well (W-815-2803) and connecting it to the 815-SRC ground water treatment system to increase hydraulic capture and contaminant mass removal in the Building 815 source area and to prevent migration of VOCs, HE compounds, and perchlorate in the Tnbs₂ HSU.
2. Converting Tnbs₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent offsite migration of VOCs, and connect it to the 815-DSB ground water treatment system (Figure 10). The well is scheduled to be connected to the 815-DSB facility in 2012.
3. Evaluating Tnbs₂ HSU monitor well W-815-2621 to determine its suitability as an extraction well to increase hydraulic capture of VOCs near the site boundary.

These wells are shown on Figures 3 and 14.

Hydraulic capture for the twelve existing HEPA facility extraction wells and the recommended new extraction wells for the 815-SRC and 815-DSB facilities will be evaluated over the next five years and documented in the Annual Compliance Monitoring Reports. Based on this data, DOE/ NNSA will pursue opportunities to optimize the HEPA OU treatment area extraction wellfield operations to maximize contaminant removal as they are identified.

6.4.2. Risk Mitigation Remediation Progress

This section summarizes the results of the annual risk re-evaluation conducted for the HEPA OU to assess the progress of the remediation effort in mitigating risk to onsite workers.

The baseline human health risk assessment estimated an excess cancer risk of 5×10^{-6} to onsite workers inhaling VOCs evaporating from subsurface soil into outdoor ambient air in the vicinity of Building 815. An excess cancer risk of 1×10^{-5} was also estimated for onsite workers inhaling TCE and 1,1-dichloroethylene (DCE) volatilizing from surface water at Spring 5.

The Compliance Monitoring Plan requires that the risk associated with volatile contaminants in the subsurface migrating upward into indoor and outdoor ambient air and being inhaled by workers be re-evaluated annually using current data. DOE/NNSA, EPA, and the State regulatory agencies agreed that the risk would be considered successfully mitigated and risk management would be complete when the estimated risk is below 10^{-6} for two consecutive years. Risk re-evaluation for VOC inhalation in outdoor air near Building 815 was initiated in 2003. As reported in the 2003 and 2004 CMRs and 2007 Five-Year Review, VOC inhalation risk was below 10^{-6} in 2003 and 2004 (Dibley et al., 2004a, 2005a, and 2007b). Therefore, the risk associated with VOCs in subsurface soil has been successfully mitigated, and risk and hazard management is complete at Building 815.

DOE/NNSA were unable to re-evaluate VOC inhalation risk to onsite workers at Spring 5 from 2003 through 2011 due to lack of water in this spring. However, the baseline risk was calculated from VOC concentrations in well W-817-03A located adjacent to Spring 5 since the actual flow in the spring is generally too low to measure and the spring consists primarily of moist soil with wetland vegetation. No one regularly works in the vicinity of Spring 5 and VOC concentrations in ground water that feeds the spring have decreased from 150 $\mu\text{g/L}$ in 1987 to 40 $\mu\text{g/L}$ in March 2011. Therefore the cancer risk estimated in the baseline risk assessment has

decreased correspondingly over time. In addition, more than half of the estimated risk resulted from the presence of 1,1-DCE, which has not been detected in ground water in the area since 1987.

On September 28, 2011, EPA released updated toxicity values and contaminant characteristics for TCE in the Integrated Risk Information System (IRIS) (EPA, 2011). Currently, only the assessment of risk for the vapor inhalation pathway is expected to be significantly impacted by this change. As agreed to with EPA and DTSC, DOE/NNSA have been using the DTSC Health and Environmental Risk Department (HERD) cancer Inhalation Unit Risk (IUR) for TCE of $2.0 \times 10^{-6} (\mu\text{g}/\text{m}^3)^{-1}$ in the calculation of cancer risk for TCE volatilizing from the subsurface into indoor air since 2005. The DTSC HERD and the new (2011) EPA cancer IUR for TCE is now $4.1 \times 10^{-6} (\mu\text{g}/\text{m}^3)^{-1}$. There is no implication for DOE/NNSA Site 300 as a result of the new EPA IUR for TCE. The new non-cancer Reference Concentration (RfC) is $2.0 \times 10^{-3} \text{ mg}/\text{m}^3$. The risk assessment for the inhalation pathway to indoor air (Building 815) was re-evaluated using the new IUR of $4.0 \times 10^{-6} (\mu\text{g}/\text{m}^3)^{-1}$ and RfC of $2.0 \times 10^{-3} \text{ mg}/\text{m}^3$. This evaluation was performed using the U.S EPA Johnson-Ettinger Model (version 3.1; 02/04 GW-ADV) updated with the new toxicity values for TCE. The resulting indoor air exposure concentration is $0.027 \mu\text{g}/\text{m}^3$. This concentration is significantly below the air concentration of $0.43 \mu\text{g}/\text{m}^3$ being protective at 10^{-6} cancer risk level and $2.1 \mu\text{g}/\text{m}^3$ being protective of non-cancer effects for residential exposure. The industrial exposure levels are $3 \mu\text{g}/\text{m}^3$ and $8.8 \mu\text{g}/\text{m}^3$ for a 10^{-6} cancer risk level and non-cancer effects, respectively. An inverse calculation to determine the maximum allowable TCE concentration in ground water beneath Building 815 results in $200 \mu\text{g}/\text{L}$ for a 10^{-6} cancer risk level and $700 \mu\text{g}/\text{L}$ for non-cancer effects for an industrial exposure scenario. The outdoor air inhalation pathway would also not result in any unacceptable risk since the current outdoor exposure concentration at the site is calculated to be $5.5 \times 10^{-14} \mu\text{g}/\text{m}^3$ using the Jury et al. (1983) model.

The baseline ecological assessment determined a risk from copper and cadmium existed for aquatic organisms, ground squirrels, and deer. Aquatic organisms are at risk from copper in shallow ground water at a location designated as Spring 5. The Toxicity Quotient using California Applied Action Levels exceeded 1 for copper in ground water samples from this location. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway Hazard Quotient exceed 1 for these species, which was driven by the oral pathway.

As part of the Baseline Ecological Risk Assessment, surveys for the presence of surface water at Spring 5, and algae and macro-invertebrate bioassays were conducted to identify the true risk to aquatic organisms. No adverse impacts were found. Similarly, site-wide population surveys to identify the risk to deer and ground squirrels found no adverse impacts.

As required by the CMP/CP, available biological survey data were reviewed to identify changes in the abundance of deer or ground squirrel over time that could indicate impacts to the populations in the HEPA OU. Available survey data were also reviewed to identify the presence of special status species. The results of the most recent review are reported in the 2010 Annual CMR (Dibley et al., 2011a). Biological survey data will again be reviewed and reported on in the 2011 Annual CMR.

In addition to evaluating the available biological survey data from the HEPA OU, the CMP/CP also requires a re-evaluation of the ecological hazard associated with cadmium in surface soil in these areas to determine if continuation of risk and hazard management measures are necessary. Part of this re-evaluation includes collecting additional surface soil samples from these areas for cadmium analysis and re-evaluating the associated ecological hazard. Soil sampling is scheduled for fall 2011 and will be reported in the Annual CMR.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the HEPA OU, however, chloride in Spring 14 was identified as requiring future review. Monitoring for chloride in Spring 14 was conducted and reported in the 2010 Annual CMR. Although the maximum chloride concentration detected in Spring 14 exceeded the maximum concentration observed in background springs, the chloride concentration in the most recent sample collected from Spring 14 was below the maximum concentration detected in the background springs. Chloride concentrations will be monitored in future samples collected from Spring 14. No information was identified during this review to question the ecological protectiveness of the remedy.

6.5. Interviews and Site Inspection

DOE/NNSA meets monthly with the EPA, RWQCB, and DTSC Remedial Project Managers (RPMs) and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of Site 300 Environmental Restoration Program staff at Site 300 that routinely inspect the: (1) extraction wellfield and treatment facilities weekly, and (2) monitoring wellfield during sampling activities. The Site 300 Environmental Restoration Program conducts self-assessment inspections of facilities and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and EPA and DTSC RPMs perform site inspections as requested. The EPA performed the construction completion inspection on February 5, 2008. The Five-Year Review Inspection was performed by DOE/NNSA on March 31, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the treatment systems and extraction wellfields are: (1) described in detail in the Site 300 Compliance Monitoring Reports that are issued semi-annually, and (2) discussed and presented in the RPM Project Updates that are issued prior to and discussed with the regulators at the monthly RPM meetings. The contents of the Project Updates are incorporated into the RPM meeting minutes that are distributed following the meetings.

7. Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the interim remedy into question.

7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- Ground water extraction and treatment is reducing contaminant concentrations in the subsurface as discussed in Section 6.4.
- System operation procedures are consistent with requirements.
- Costs have generally been within budget, except when extra costs were incurred to address unanticipated problems or regulatory requests.
- Ground water extraction and treatment systems are performing as designed and will continue to be operated and optimized. Examples of types of optimization that may be considered include installing new extraction wells, adding higher capacity pumps to maximize yield and to increase hydraulic capture, and upgrading the treatment facilities to accommodate increased flow, where appropriate.
- No early indicators of potential interim remedy failure were identified.
- Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

The assumptions used in the decision-making process was determined to still be valid because:

- There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
 - There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
 - No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified.
 - There have been no changes in land, building, or water use. As discussed in Section 3.2, Site 300 will be transitioning to the Hetch Hetchy water supply in the future.
 - No new contaminant sources have been identified. In April 2008, nitrobenzene was detected for the first time in the HEPA Tnbs₂ ground water in a sample from the 817-SRC extraction well W-817-01 at a concentration of 6.2 µg/L, and in a sample collected from the influent to the 815-SRC GWTS at a concentration of 4.1 µg/L. Nitrobenzene was not detected above its reporting limit in additional samples collected from W-817-01 and the influent to 815-SRC GWTS. During the first semester 2011, nitrobenzene was not detected above the 2 µg/L reporting limit in any HEPA ground water samples. DOE/NNSA continue to monitor for nitrobenzene in Tnbs₂ ground water in the HEPA OU.
 - No remedy byproducts have been identified.

- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
 - The State of California established a Maximum Contaminant Level (MCL) (6 µg/L) for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
 - The EPA National Pollution Discharge Elimination System (NPDES) Pesticide Rule changed in 2011, however, no Site 300 treatment systems currently discharge to the ground surface or fall under an NPDES permit.
- Changes in toxicity and other contaminant characteristics:
 - On September 28, 2011, EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, only the assessment of risk for the vapor inhalation pathway is expected to be significantly impacted by this change. As discussed in Section 6.4.2, the Baseline Risk Assessment identified an excess cancer risk of 5×10^{-6} to onsite workers inhaling VOCs evaporating from subsurface soil into outdoor ambient air in the vicinity of Building 815 and an excess cancer risk of 1×10^{-5} for onsite workers inhaling VOCs volatilizing from surface water at Spring 5. The Building 815 risk was mitigated in 2003 and the Spring 5 risk has not been reevaluated due to lack of water since 2003. However, no one regularly works in the vicinity of Spring 5 and VOC concentrations in ground water that feeds the spring have decreased from 150 µg/L in 1987 to 40 µg/L in March 2011. The indoor and outdoor inhalation risk for Building 815 was re-evaluated using the new toxicity values. As discussed in Section 6.4.2, the new toxicity values do not result in any unacceptable cancer risk or non-cancer effects for Building 815. DOE/NNSA will review the impact of changes with the regulators and assess the need for further evaluation.
- The review found progress toward meeting the RAOs.

7.3. Other Information

The EPA identified a lack of institutional controls in the HEPA OU that would prevent the private land owner from installing water-supply and agricultural wells in the offsite VOC plume above cleanup standards, and to prevent the consumption of contaminated water in offsite well GALLO1. As discussed in the Summary Form, Section 4.4.2.2 (Prevent Offsite Water-supply Use/consumption of Contaminated Ground Water), and Section 9 (Recommendations and Follow-Up Actions), DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend that the property owner include a provision in the MOU that formally documents that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1.

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- No unanticipated events (i.e., natural disasters, new contaminants discovered) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the HEPA OU.

8. Issues

As discussed in the Summary Form, Section 4.4.2.2 and Section 7.3, there is no MOU and/or other institutional controls to prevent the installation of offsite water-supply or agricultural wells within the VOC plume, or to prevent the consumption of contaminated water in offsite well GALLO1. DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend that the property owner include a provision in the MOU that formally documents that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1.

9. Recommendations and Follow-Up Actions

The following recommendations were developed during the review process and will be carried out by the DOE/NNSA:

1. Install one new extraction well (W-815-2803) to increase hydraulic capture and contaminant mass removal in the Building 815 source area and to prevent migration of VOCs, HE compounds, and perchlorate in the Tnbs₂ HSU (Figure 10). This extraction well will be connected to the Building 815-Source (815-SRC) treatment facility. The well is scheduled to be drilled in 2012 and will be connected to 815-SRC in 2014.
2. Convert Tnbs₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent further offsite migration of VOCs, and connect it to the 815-Distal Site Boundary (DSB) ground water treatment system (Figure 10). The well is scheduled to be connected to the 815-DSB facility in 2012.
3. Evaluate Tnbs₂ HSU monitor well W-815-2621 to determine its suitability as an extraction well for the 815-DSB wellfield by the next Five-Year Review in 2016.
4. Install one new well (W-817-2XM1) to monitor HE compound, perchlorate, and nitrate concentrations near the 817-SRC treatment facility in the Tnbs₂ HSU (Figure 10). This monitor well will assess the effectiveness of the 817-SRC recirculation cell between extraction well W-817-01 and effluent injection well W-817-06A. This well is scheduled to be drilled in 2014.

5. Install one new well (W-815-2XM1) to monitor VOCs, HE compounds, perchlorate, and nitrate concentrations near the Building 815 source area in the Tpsg-Tps HSU (Figure 20). This well is scheduled to be drilled in 2014.
6. Evaluate Tnbs₂ HSU well W-817-2609 in the 817-Proximal area by monitoring contaminant concentrations in this well and nearby well W-817-03 to determine whether to convert well W-817-2609 to an extraction well (Figure 10) by the next Five-Year Review in 2016.
7. Identify potential locations for two additional effluent injection wells to allow 817-PRX wellfield extraction rates to be increased in the Tnbs₂ HSU by the next Five-Year Review in 2016.
8. DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend that the property owner include a provision in the MOU to formally document that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1.

Operation of and hydraulic capture zones for existing and recommended new extraction wells in the HEPA OU will be evaluated over the next five years and documented in the Annual Compliance Monitoring Reports. Based on these data, DOE/NNSA will pursue opportunities to optimize wellfield operations to maximize contaminant removal as they are identified.

No other follow-up actions were identified related to this Five-Year Review.

10. Protectiveness Statement

The remedy at the HE Process Area OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination and remedial treatment systems are effectively treating ground water. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. However, in order for the remedy to be protective in the long-term, institutional controls will be implemented to prevent potential future exposure to offsite ground water contamination.

A VOC plume in the Tnbs₂ HSU with concentrations above MCL cleanup standards originating from the HEPA OU extends approximately 100 ft offsite in the vicinity of monitor wells W-35B-04 and -05. While active private offsite water-supply well GALLO1 is located upgradient from the VOC plume, an evaluation of ground water elevation data indicate that the pumping of GALLO1 is drawing the VOC plume towards it. Historically, TCE has been sporadically detected at low concentrations (<1 µg/L) above the 0.5 µg/L reporting limit but below the 5 µg/L drinking water MCL cleanup standard in ground water samples in offsite water-supply well GALLO1.

There is no MOU and/or other institutional controls to prevent the installation of offsite water-supply or agricultural wells within the offsite portion of the VOC plume originating from the HEPA OU. In addition, while LLNL notified the owner of TCE detections in GALLO1 and

DOE offered to provide point-of-use treatment at this well, there is no Memorandum of Understanding (MOU) that formally documents that DOE would provide point-of-use treatment at GALLO1 to prevent the consumption of contaminated water from this well.

Therefore, DOE will initiate discussions with the owners of the property on which the offsite portion of the HEPA OU VOC plume is located to discuss/negotiate a MOU and/or other institutional controls to prevent the installation of water-supply or agricultural wells within the VOC plume until concentrations have been reduced to meet cleanup standards. In addition, DOE will recommend that the property owner include a provision in the MOU to formally document that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in the offsite water-supply well GALLO1. The remedy will be protective in the long-term, once the MOU is in place.

The cleanup standards for HEPA OU ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

The cleanup standards for VOCs in subsurface soil are to reduce concentrations to mitigate risk to onsite workers and prevent further impacts to ground water to the extent technically and economically feasible. Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. The land use control consists of implementing a land use covenant per Title 22 California Code of Regulations (CCR), Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h) in the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future. This land use control requirement is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

11. Next Review

The next statutory review will be conducted within five years of the signature date of this report (2017).

12. References

- Crow, N.B., R. Elwood, and P. Webster-Scholten (1986), *Distribution of High Explosive Compounds in Soil and Water at the 806/807 Lagoons, HE Process Area, LLNL Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10169).
- Dibley, V., R. Blake, T. Carlsen, M. Denton, R. Goodrich, S. Gregory, K. Grote, V. Madrid, C. Stoker, M. Taffet, J. Valett (2004a), *2003 Annual Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319).
- Dibley, V., R. Blake, T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, J. Valett (2004b), *First Semester 2004 Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-04).
- Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, and J. Valett (2005a), *2004 Annual Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-04).
- Dibley, V., J. Valett, L. Ferry (2006a), *Five-Year Review Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-220827).
- Dibley, V., J. Valett, S. Gregory, and V. Madrid (2007a), *Five-Year Review Report for the Building 834 Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-226628).
- Dibley, V., V. Madrid, and M. Denton (2007b), *Five-Year Review Report for the High Explosive Process Area Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-232231).
- Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, J. Valett (2007d), *First Semester 2007 Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-07).
- Dibley, V., L. Ferry, M. Taffet, G. Carli, and E. Friedrich (2008a), *Engineering Evaluation/Cost Analysis for PCB-, Dioxin, and Furan-contaminated Soil at the Building 850 Firing Table, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-233862).
- Dibley, V., L. Ferry, M. Taffet (2008b), *Action Memorandum for the Removal Action at the Building 850 Firing Table, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (LLNL-AR-403206).
- Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, D. Mason, P. McKereghan, M. Taffet, J. Valett (2008c), *2007 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-07).

- Dibley, V., J. Valett, and M. Buscheck (2009a), *Five-Year Review Report for the Building 854 Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-404822).
- Dibley, V., L. Ferry, S. Gregory, L. Hall, V. Madrid, L. Martello, E.N. Shiroma, M. Taffet, K.S. Wells (2009b), *Compliance Monitoring Plan/Contingency Plan for Environmental Restoration at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (LLNL-AR-411239).
- Dibley, V., L. Ferry, M. Buscheck, Ed. (2009c), *2008 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-08).
- Dibley, V., L. Ferry, M. Buscheck, Ed. (2009d), *First Semester 2009 Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-09).
- Dibley, V., L. Ferry, M. Buscheck, Ed. (2010a), *2009 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-09).
- Dibley, V., L. Ferry, M. Buscheck, Ed. (2010b), *First Semester 2010 Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-10).
- Dibley, V., L. Ferry, M. Buscheck, Ed. (2011a), *2010 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-10).
- Dibley, V., L. Ferry, M. Taffet, Z. Demir, V. Madrid, K. Moffitt, R. Ruiz, (2011b), *Remedial Action Completion Report for the Building 850/Pit 7 Complex Operable Unit Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (LLNL-AR-432791).
- Dibley, V., L. Ferry, M. Buscheck, Ed. (2011c), *First Semester 2011 Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-11).
- Ferry L. and C. Holtzapple (2005), *Characterization Summary Report for the Building 812 Study Area at Lawrence Livermore National Laboratory Site 300*, U.S. Department of Energy and Lawrence Livermore National Laboratory, Livermore Calif., 21 pp. plus attachments.
- Ferry L. and C. Holtzapple (2006), *Characterization Summary Report for the Building 865 Study Area at Lawrence Livermore National Laboratory Site 300*, U.S. Department of Energy and Lawrence Livermore National Laboratory, Livermore Calif., 35 pp. plus attachments.
- Ferry, L., R. Ferry, W. Isherwood, R. Woodward, T. Carlsen, Z. Demir, R. Qadir, and M. Dresen (1999), *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore Calif. (UCRL-AR-132609).
- Ferry, L., M. Dresen, Z. Demir, V. Dibley, V. Madrid, M. Taffet, S. Gregory, J. Valett, M. Denton (2006), *Final Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-220391).

- Ferry, R., W. Daily, L. Ferry, G. Aarons, V. Madrid, J. Valett, Z. Demir (2001a), *Five-Year Review Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-14104).
- Ferry, R., M. Dresen, L. Ferry, W. Isherwood, and J. Ziagos (2001b), *Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-138470).
- Ferry, R., L. Ferry, S. Gregory, V. Madrid, J. Valett, (2002a), *Five-Year Review Report for the Building 834 Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-144744).
- Ferry, R., L. Ferry, M. Dresen, and T. Carlsen (2002b), *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-147570).
- Ferry L., V. Madrid, S. Gregory, A. Helmig (2010), *Explanation of Significant Difference for Ground Water Nitrate Treatment at the Building 829-Source Treatment Facility Remedies at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (LLNL-AR-454953).
- Goodrich, R., and G. Lorega (Eds.) (2009), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)*, Lawrence Livermore National Laboratory Livermore, Calif. (UCRL-MA-109115 Rev. 13).
- Helmig, A., V. Dibley, V. Madrid, and J. Valett (2011), *Five-Year Review Report for the Building 832 Canyon Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-470073).
- Henry R.K., and P.A. Smuda (1981), *Engineering Report: Industrial Wastewater Discharges at Lawrence Livermore National Laboratory, Site 300*, Administrative Document, Lawrence Livermore National Laboratory, Livermore, Calif.
- Holtzapple, C. (2005), Excavation of polychlorinated biphenyl-contaminated soil at the Building 855 lagoon at Lawrence Livermore National Laboratory (LLNL) Site 300, Lawrence Livermore National Laboratory, Livermore, Calif. (letter report).
- Holtzapple, C. (2008), Construction Completion Report for the Pit 6 Landfill Operable Unit at Lawrence Livermore National Laboratory (LLNL) Site 300, Lawrence Livermore National Laboratory, Livermore, Calif. (letter report).
- Jakub, B.J. (1998), *Action Memorandum for the Building 815 Operable Unit Removal Action Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif.
- Jury, W.A., Spencer, W.F., Farmer, W.J. (1983), *Behavior assessment models for trace organics in soil: I. Model description*. J. Environ. Qual. 12, 558-564. (Errata see: J. Environ. Qual. 16, 448).
- Lamarre, A.L., H.K. Otsuki, T.D. Epley, D.W. Carpenter, K.G. Fischer, S. Mathews, E.L. Miner, and K.C. Sixt (1997), *Final Closure Plan for the High-Explosives Open Burn Facility at Building 829*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-ID-111753 Rev. 1).

- LLNL (2004), *Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation*, Lawrence Livermore National Laboratory, Livermore, Calif.
- LLNL (2008), *First Semester 2008 Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-08).
- Madrid, V.M. and B.J. Jakub (1998), *Engineering Evaluation/Cost Analysis for the Building 815 Operable Unit Removal Action Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-126639).
- Madrid, V., L. Ferry, A. Ritcey, J. Valett, and M. Verce (2002), *Interim Remedial Design for High Explosives Process Area Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-147095).
- Madrid, V.M., H.R. Beller, B. Esser, G.B. Hudson, M. Singleton, W. McNab, and S. Wankel (2006), *Evaluation of Sources and Fate of Groundwater Nitrate at a Semi-arid Catchment in the Central California Coast Ranges using Stable Isotopes*, Groundwater Resources Association, 17th Symposium in the Series on Groundwater Contaminants, Nitrate in California's Groundwater: Are We Making Progress? April 4–5, 2006, Modesto, California (UCRL-ABS-218111).
- Martins, S. (2007), *LLNL Environmental Restoration Division, Operations and Maintenance Manual, Volume XIII: Miniature Treatment Units (MTUs), Granular Activated-Carbon Units (GTUs), and Solar Treatment Units (STUs)*, Lawrence Livermore National Laboratory, Calif.
- Taffet, M.J., L. Ferry, V. Madrid, T. Carlsen, Z. Demir, J. Valett, M. Dresen, W. Daily, S. Coleman, V. Dibley (2005), *Final Remedial Investigation/Feasibility Study for the Pit 7 Complex at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-202492).
- U.S. DOE (1995), *Interim Record of Decision for the Building 834 Operable Unit Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-119791).
- U.S. DOE (1997), *Final Record of Decision for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-124061).
- U.S. DOE (2001), *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-138470).
- U.S. DOE (2002), *Draft Department of Energy CERCLA Five-Year Review Guidance*, U.S. Department of Energy, Washington, D.C.
- U.S. DOE (2007), *Amendment to the Interim Site-Wide Record of Decision for the Pit 7 Complex at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-222569).
- U.S. DOE (2008), *Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-236665).

- U.S. EPA (2001), *Comprehensive Five-Year Review Guidance*, U.S. Environmental Protection Agency (EPA 540-R-01-007), OSWER Directive 9355.7-03B-P.
- U.S. EPA (2005), Perchlorate, U.S. EPA Federal Facilities Restoration and Reuse web page, <http://www.epa.gov/fedfac/documents/perchlorate.htm>.
- U.S. EPA (2011). Toxicological review of Trichloroethylene (CASRN 79-01-6) in support of summary information on the Integrated Risk Information System (IRIS). EPA/635/R-09/011F.
- Valett, J., V. Dibley, V. Madrid, L. Ferry (2011), Five-Year Review Report for the General Services Area Operable Unit, Lawrence Livermore National Laboratory, Livermore, Calif. (LLNL-AR-486703).
- Valett, J., V. Dibley, V. Madrid, L. Ferry (2012), Draft Five-Year Review Report for the Building 834 Operable Unit, Lawrence Livermore National Laboratory, Livermore, Calif. (LLNL-AR-DRAFT).
- Webster-Scholten C.P., Ed. (1994), *Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-MI-141567).

13. Acronyms and Abbreviations

1,1,1-TCA	1,1,1-Trichloroethane
ARARs	Applicable or relevant and appropriate requirements
ATA	Advanced Test Accelerator
bgs	Below ground surface
BTU	Biotreatment Unit
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Contaminant of concern
CTR	California Toxics Rule
DCE	Dichloroethylene
DNAPL	Dense non-aqueous phase liquid
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
ERD	Environmental Restoration Department
ESD	Explanation of Significant Difference
ft	Feet
GAC	Granular activated carbon
Gpd	Gallons per day
gpm	Gallons per minute
GSA	General Services Area
GWTS	Ground water extraction and treatment system
HE	High explosives
HMX	High-Melting Explosive
HSU	Hydrostratigraphic unit
IRIS	Integrated Risk Information System
kg	Kilogram
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security
LNAPL	Light non-aqueous phase liquid
MCL	Maximum contaminant level
mg/kg	Milligrams per kilograms
mg/L	Milligrams per liter
MOU	Memorandum of Understanding
MNA	Monitored natural attenuation
NNSA	National Nuclear Security Administration
O&M	Operation and maintenance
OU	Operable unit
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethylene

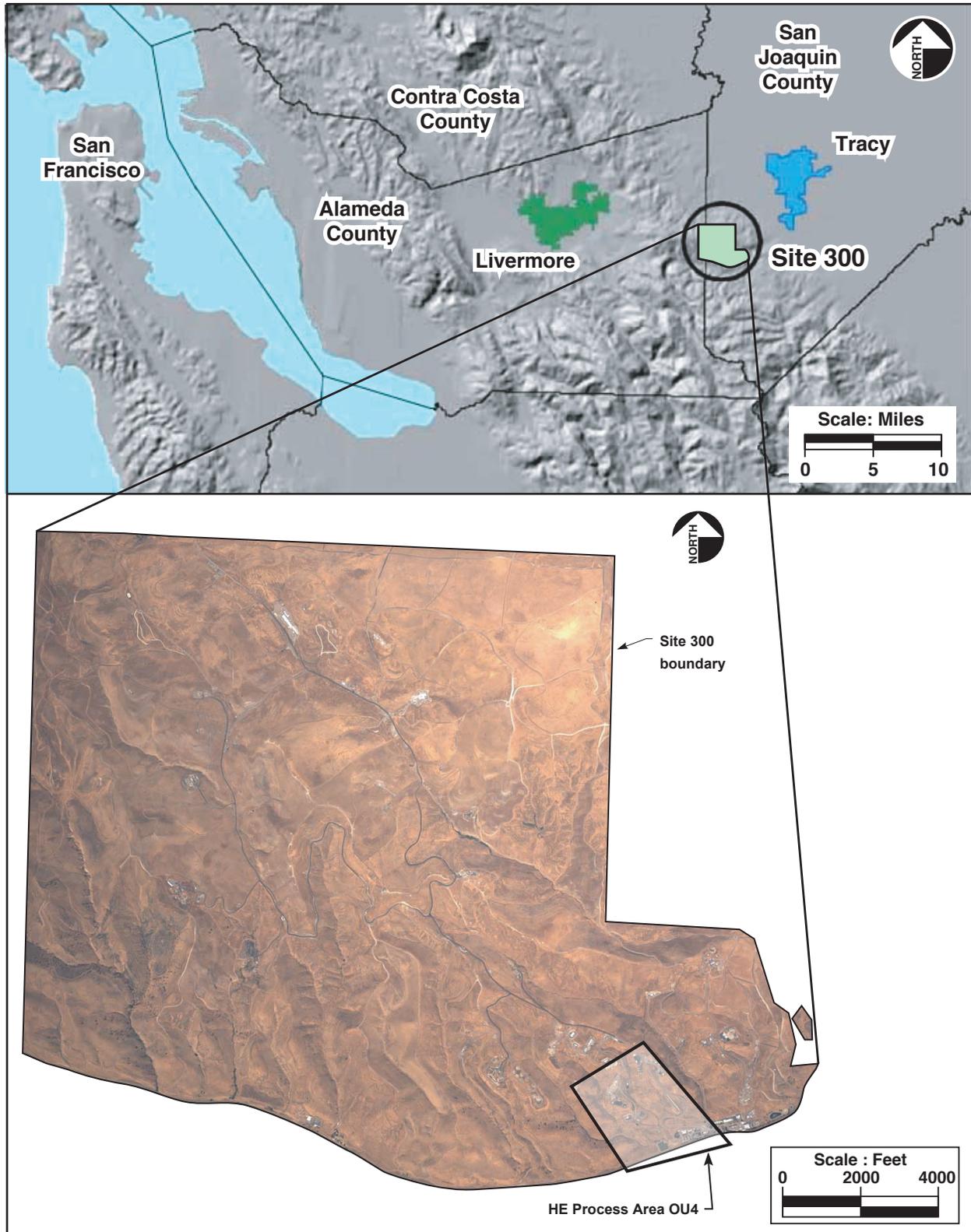
pCi/L	PicoCuries per liter
ppm _{v/v}	Parts per million on a volume per volume basis
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RDX	Research Department explosive
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPMs	Remedial Project Managers
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendment Reauthorization Act
scfm	Standard cubic flow per minute
SVTS	Soil vapor extraction and treat system
TBOS/TKEBS	Tetrabutyl orthosilicate/ Tetrakis (2-ethylbutyl) silane
TCA	Trichloroethane
TCE	Trichloroethylene
TFRT	Treatment Facility Real-Time Monitoring System
THMs	Total trihalomethanes
Tnbs ₁	Tertiary Neroly Lower Blue Sandstone
Tnbs ₂	Tertiary Neroly Upper Blue Sandstone
Tnsc ₁	Tertiary Neroly Lower Siltstone/Claystone
Tnsc ₂	Tertiary Neroly Upper Siltstone/Claystone
Tps	Tertiary Pliocene nonmarine sediments
Tpsg	Tertiary Pliocene sand and gravel
U.S.	United States
VOCs	Volatile organic compounds
yd ³	Cubic yards
µg/L	Micrograms per liter

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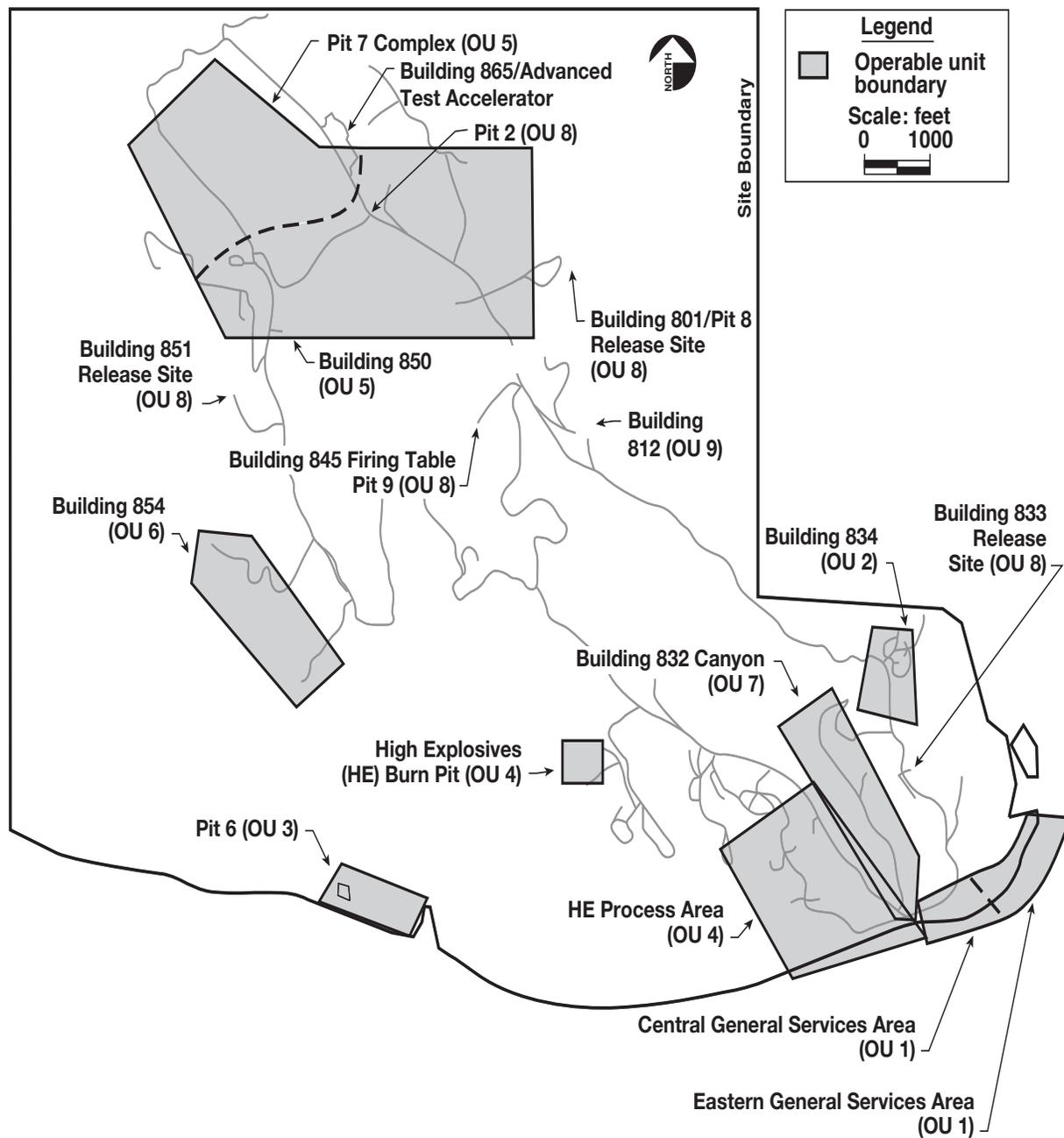
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Figure 1. Location of LLNL Site 300 and the High Explosives (HE) Process Area Operable Unit.



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Figure 2. Site 300 map showing Operable Unit locations.

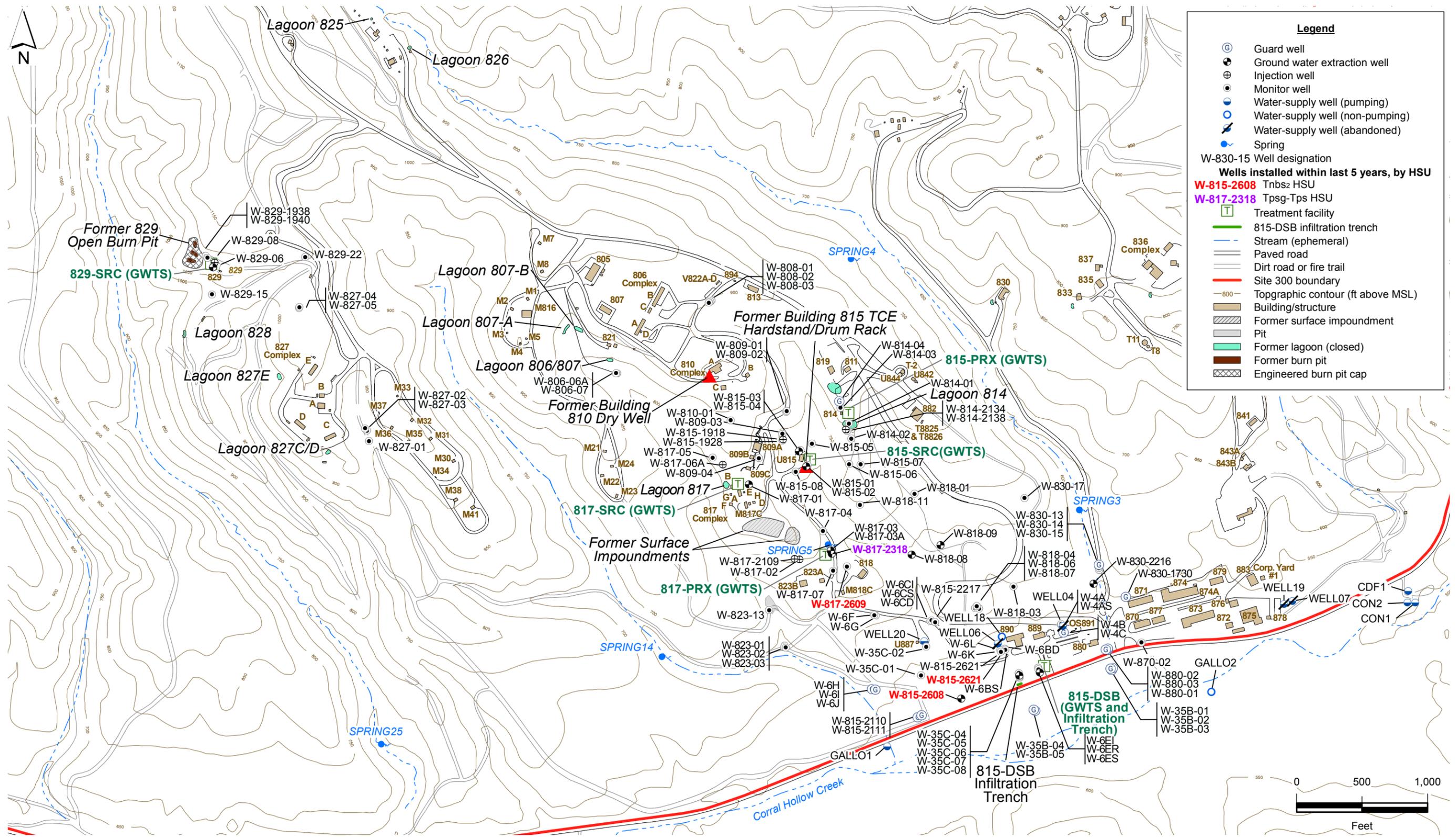
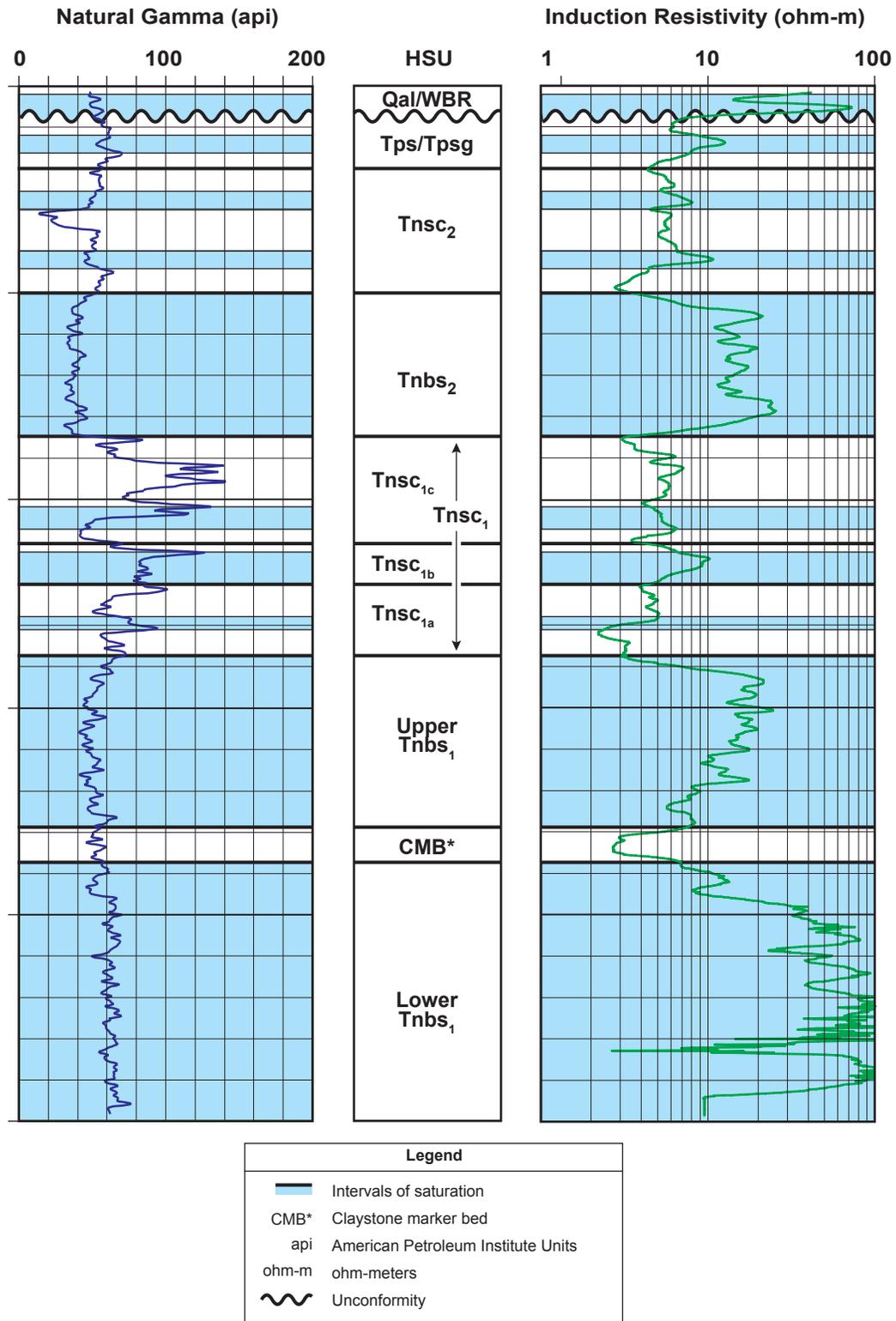
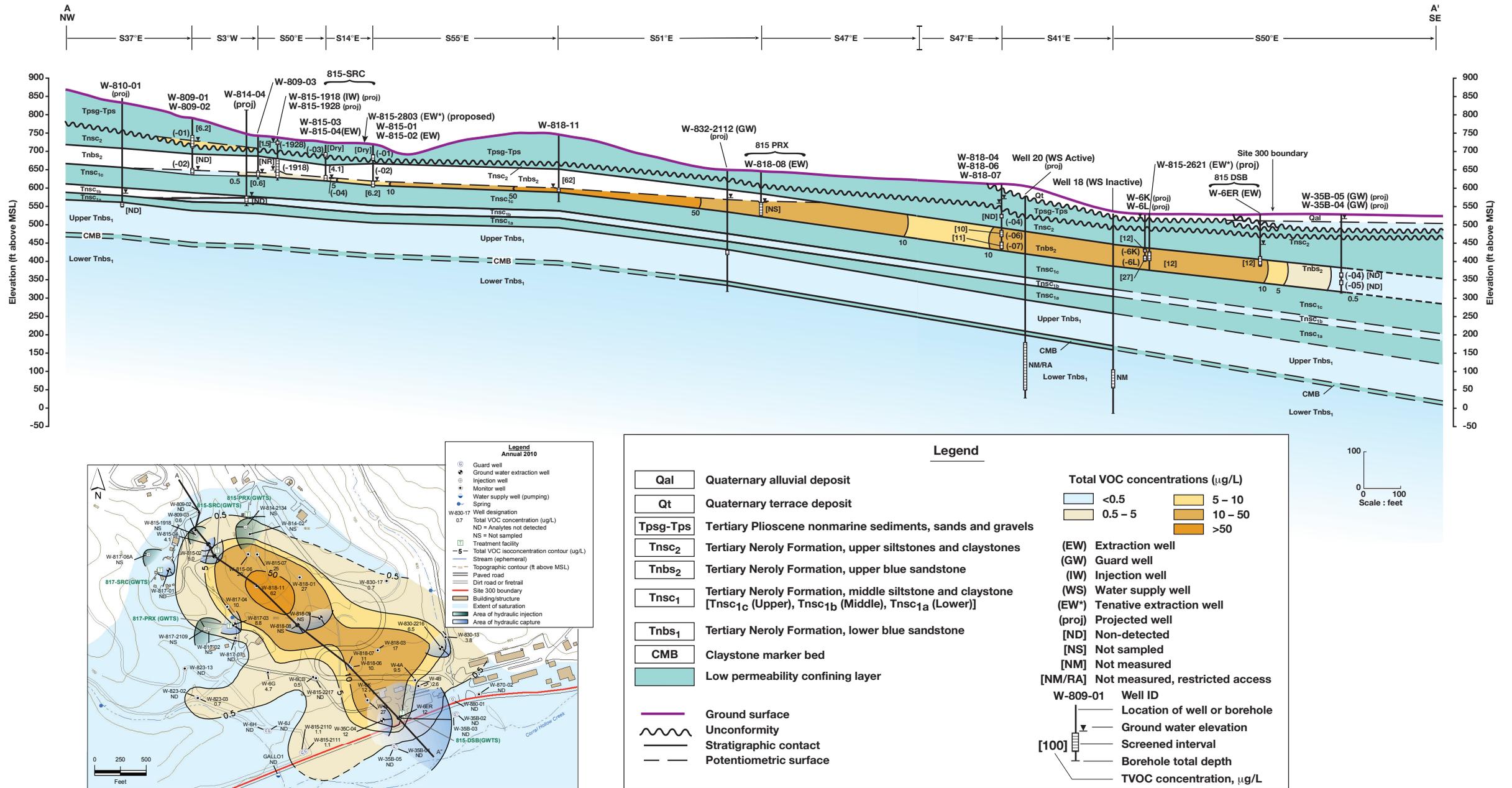


Figure 3. Site map showing monitor, extraction, injection and water-supply wells, and treatment facilities.



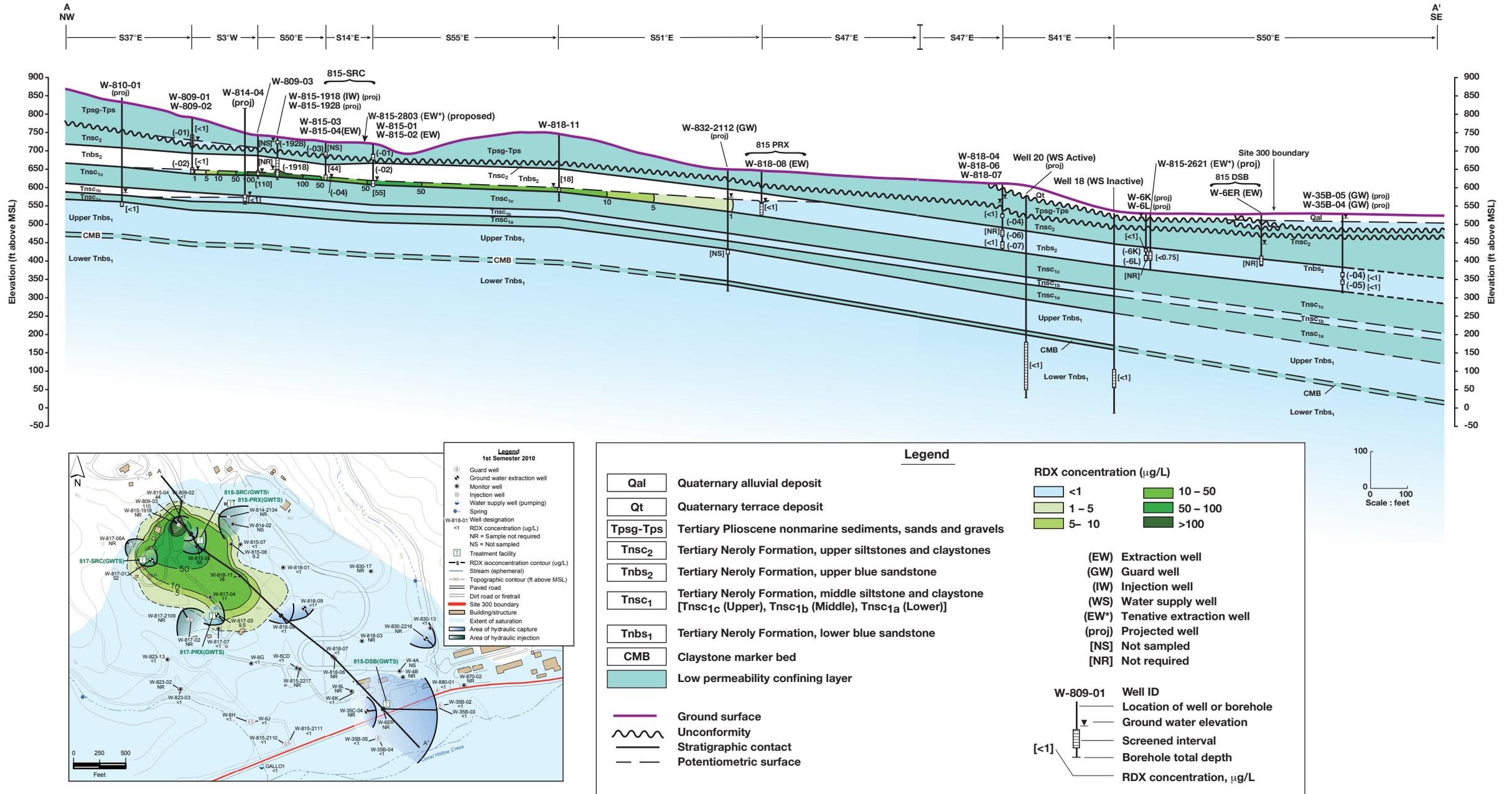
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Figure 4. Summary of stratigraphy and hydrostratigraphy.



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Figure 5. Hydrogeologic Cross-section A-A' showing total VOC concentrations.



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Figure 7. Hydrogeologic Cross-section A-A' showing RDX concentrations.

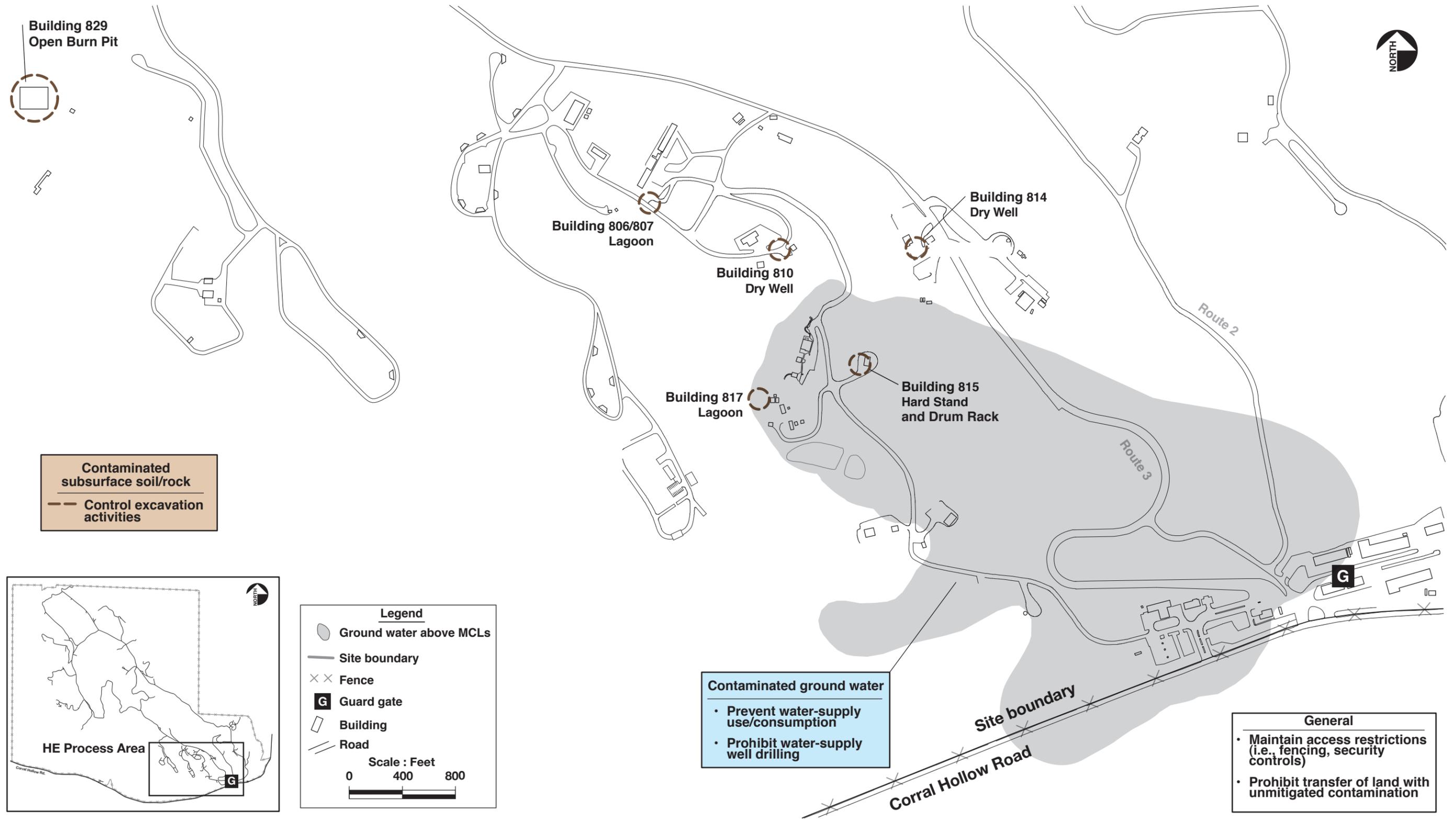
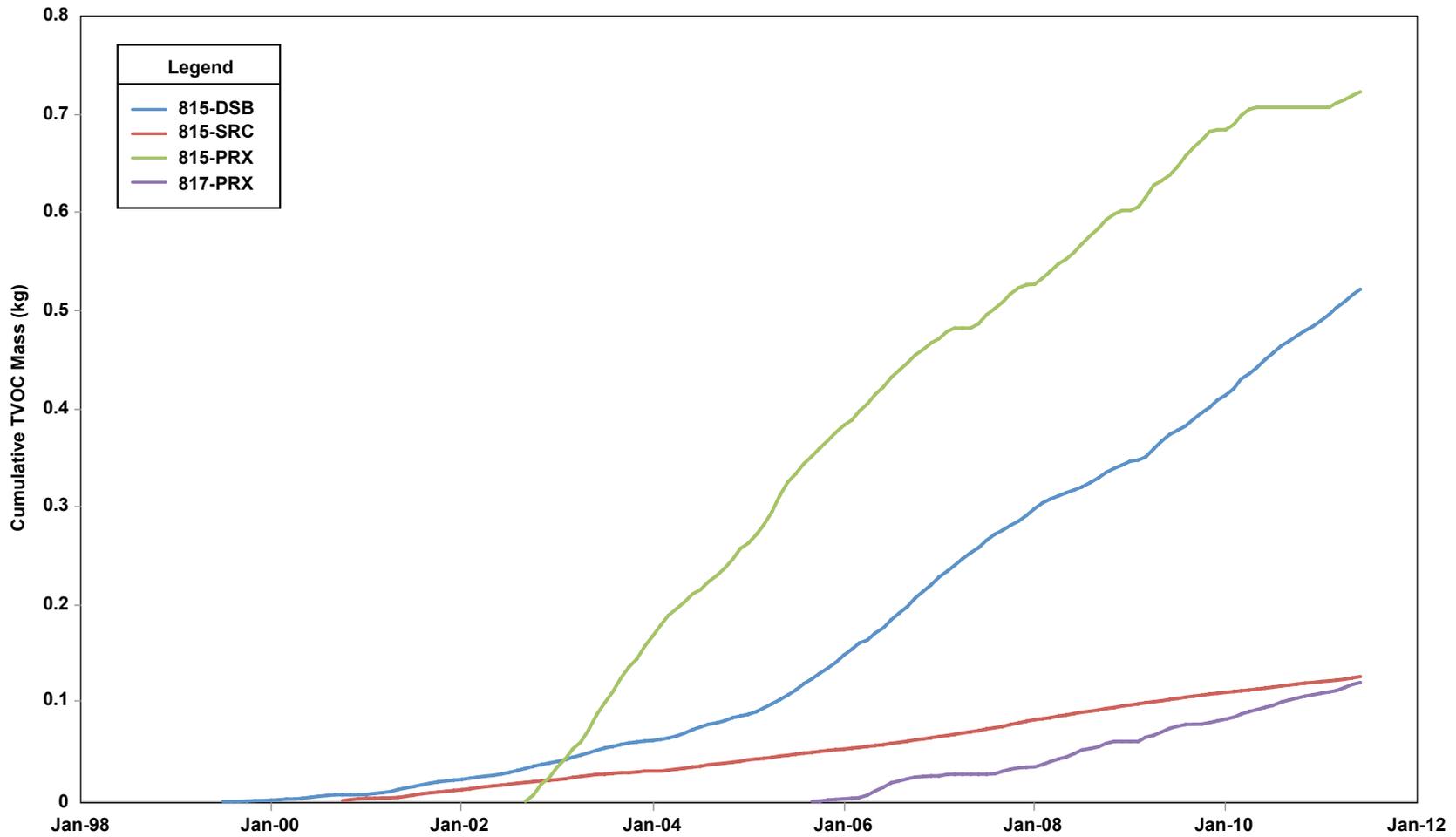
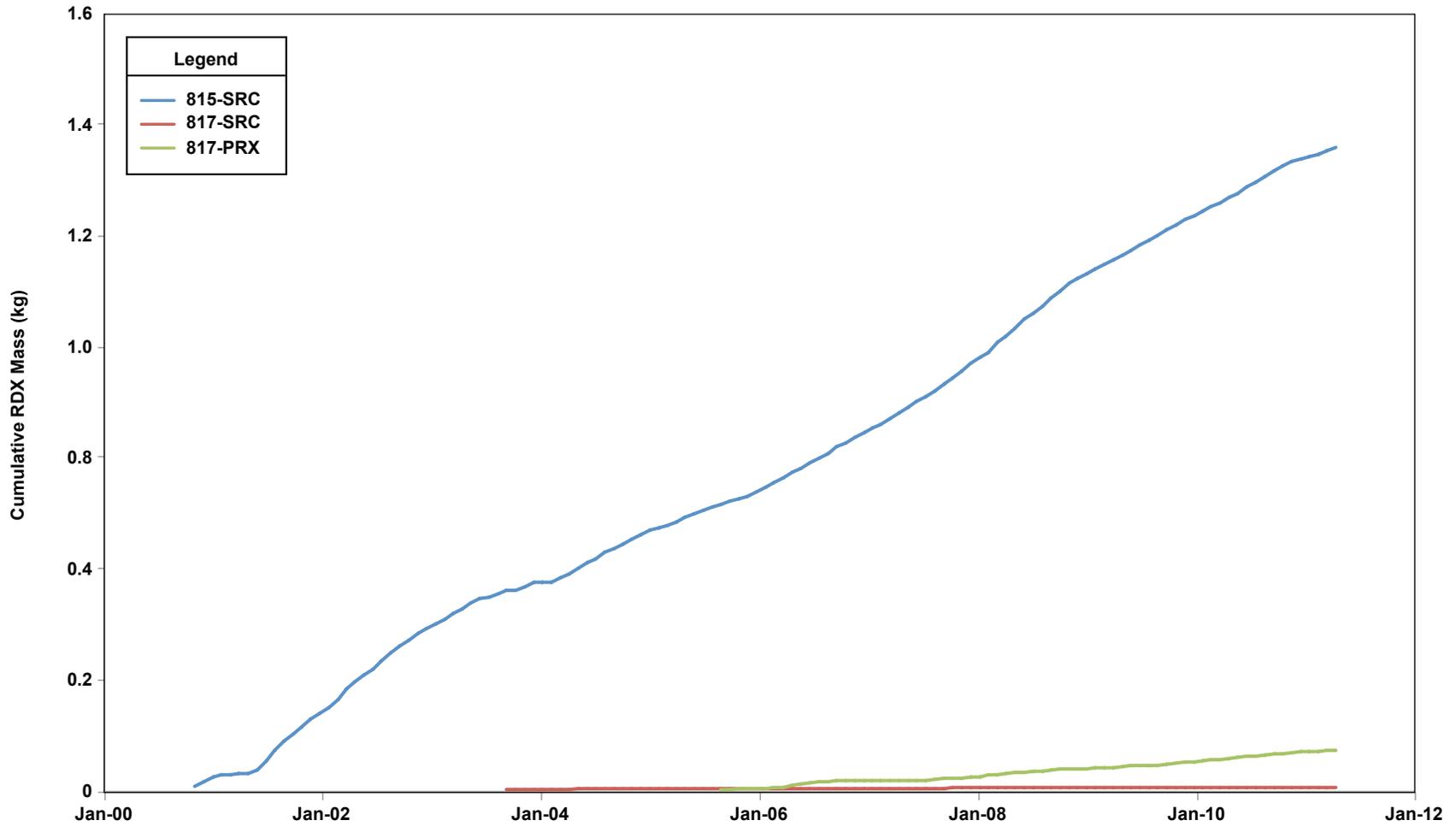


Figure 8. Institutional/land use controls.



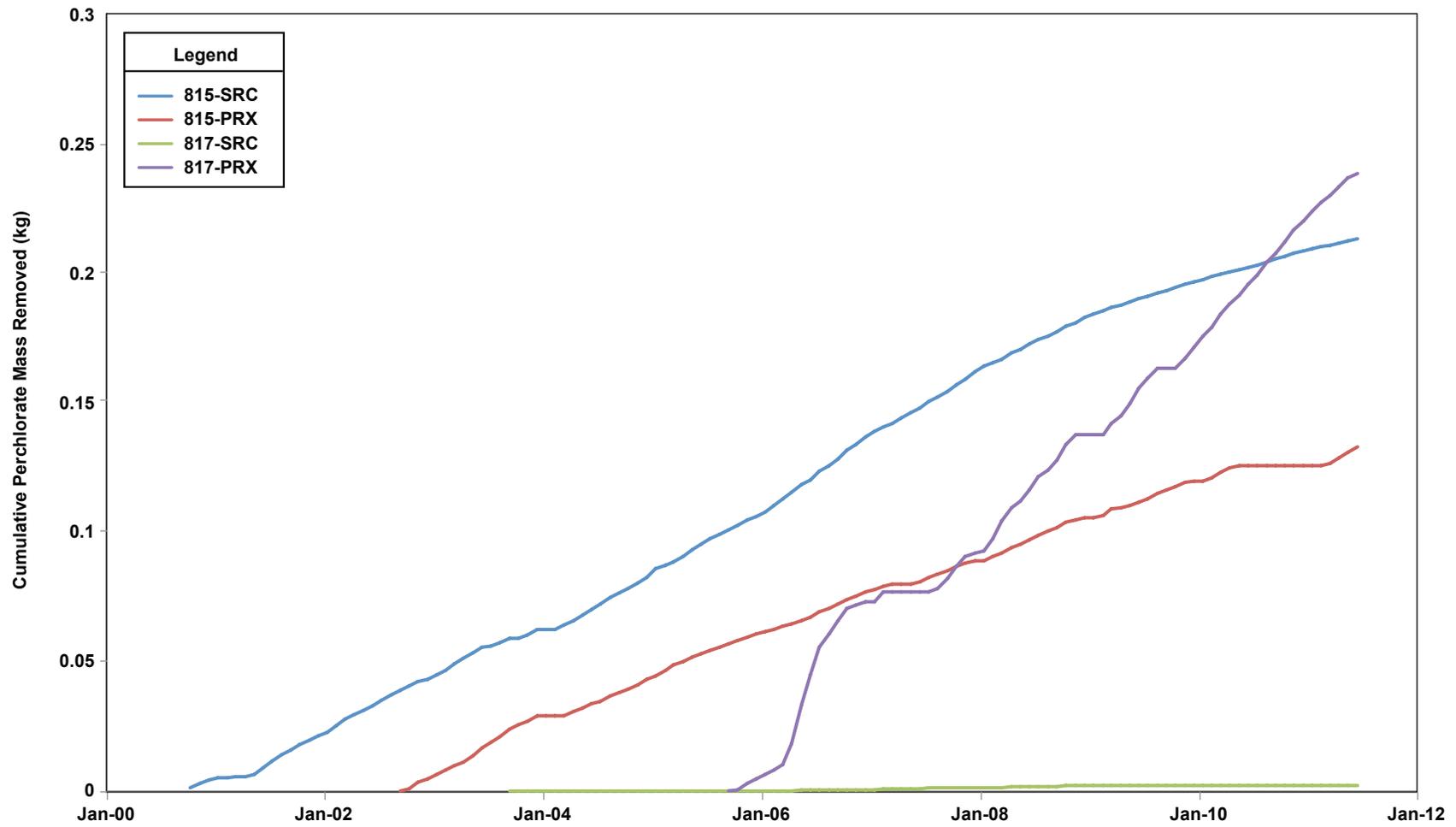
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Figure 9. Time-series plots of cumulative mass of total VOCs removed by ground water extraction per treatment facility.



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Figure 10. Time-series plots of cumulative mass of RDX removed by ground water extraction per treatment facility.



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Figure 11. Time-series plots of cumulative mass of perchlorate removed by ground water extraction per treatment facility.

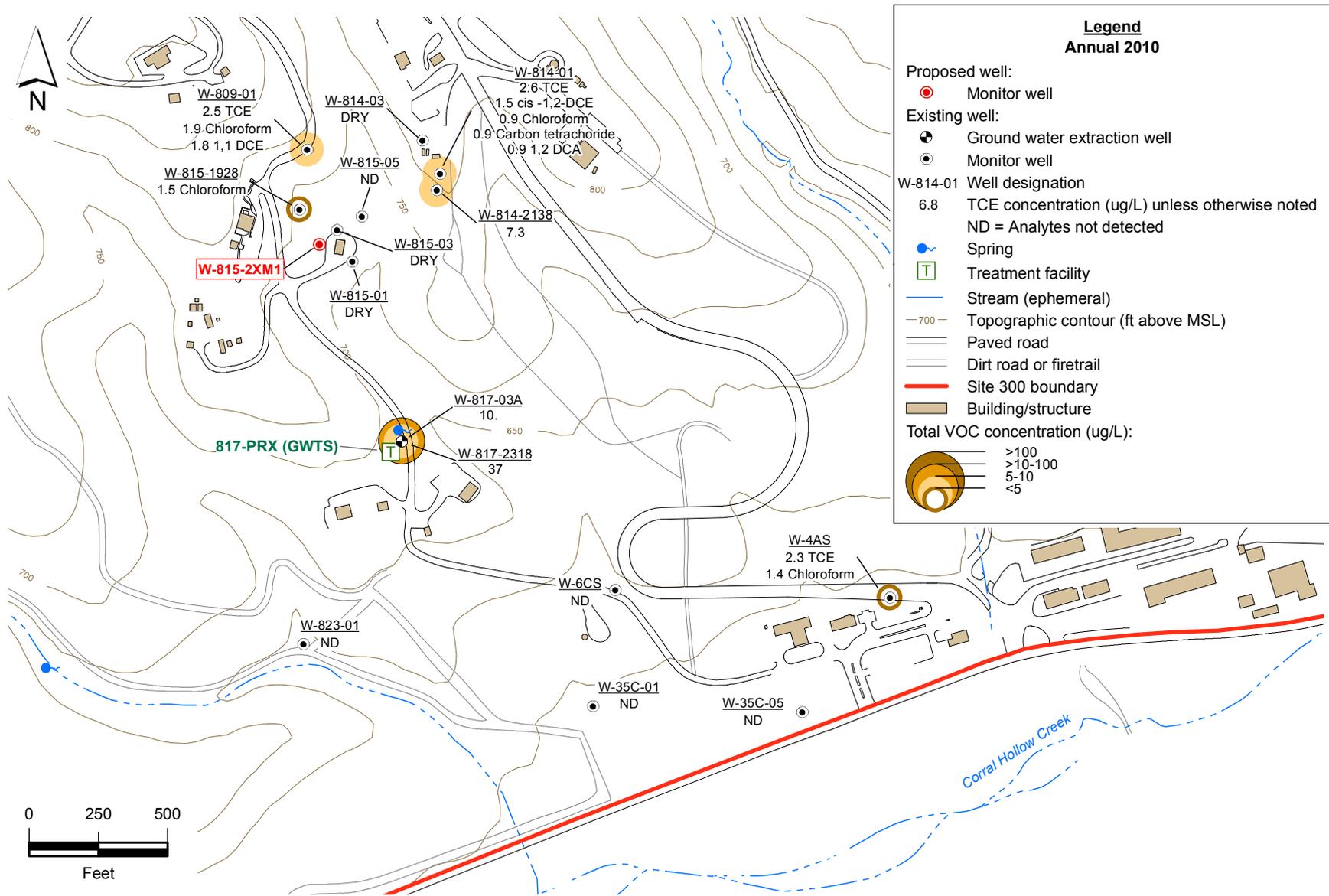


Figure 12. Map showing total VOC concentrations for the Tpsg-Tps hydrostratigraphic unit.

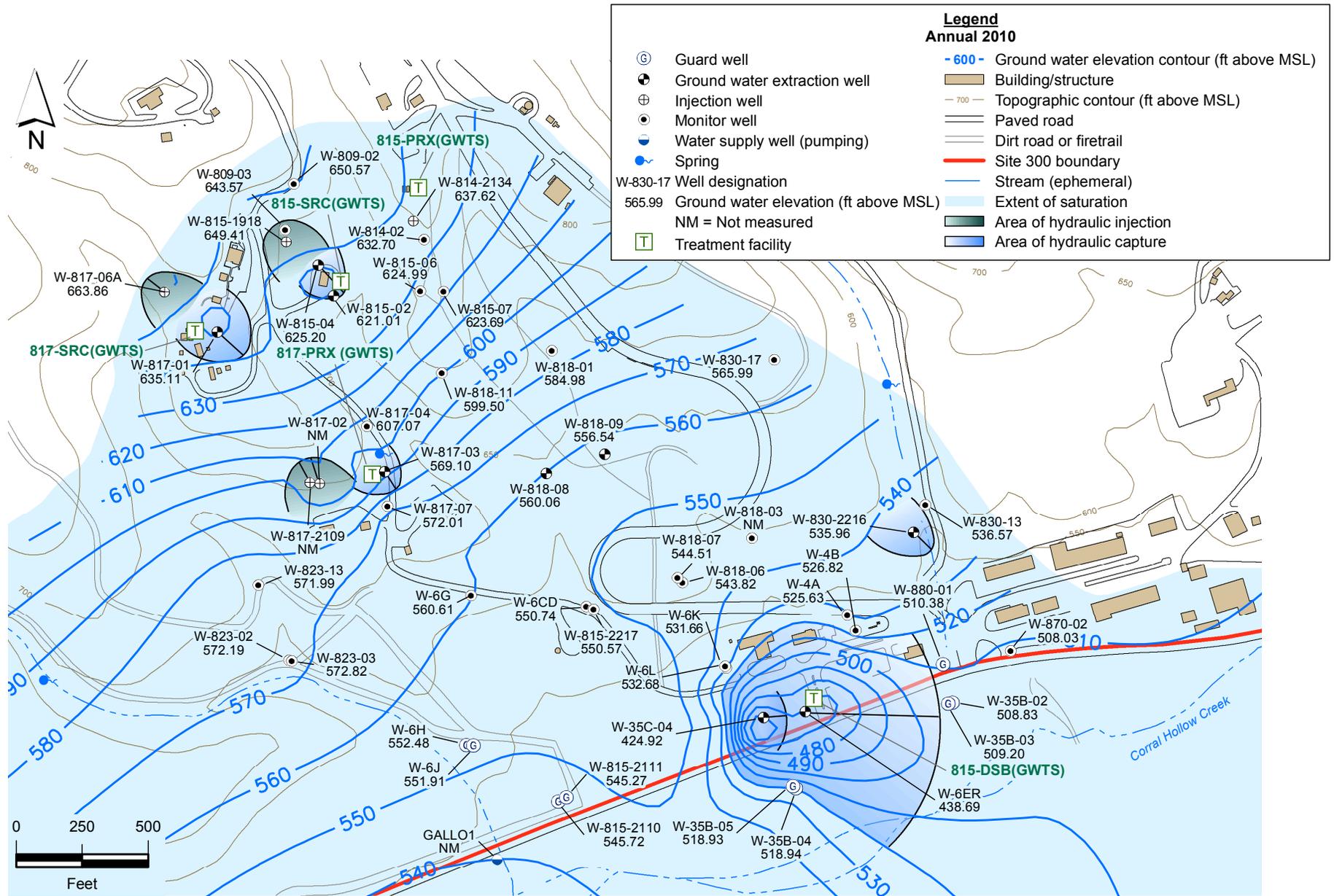


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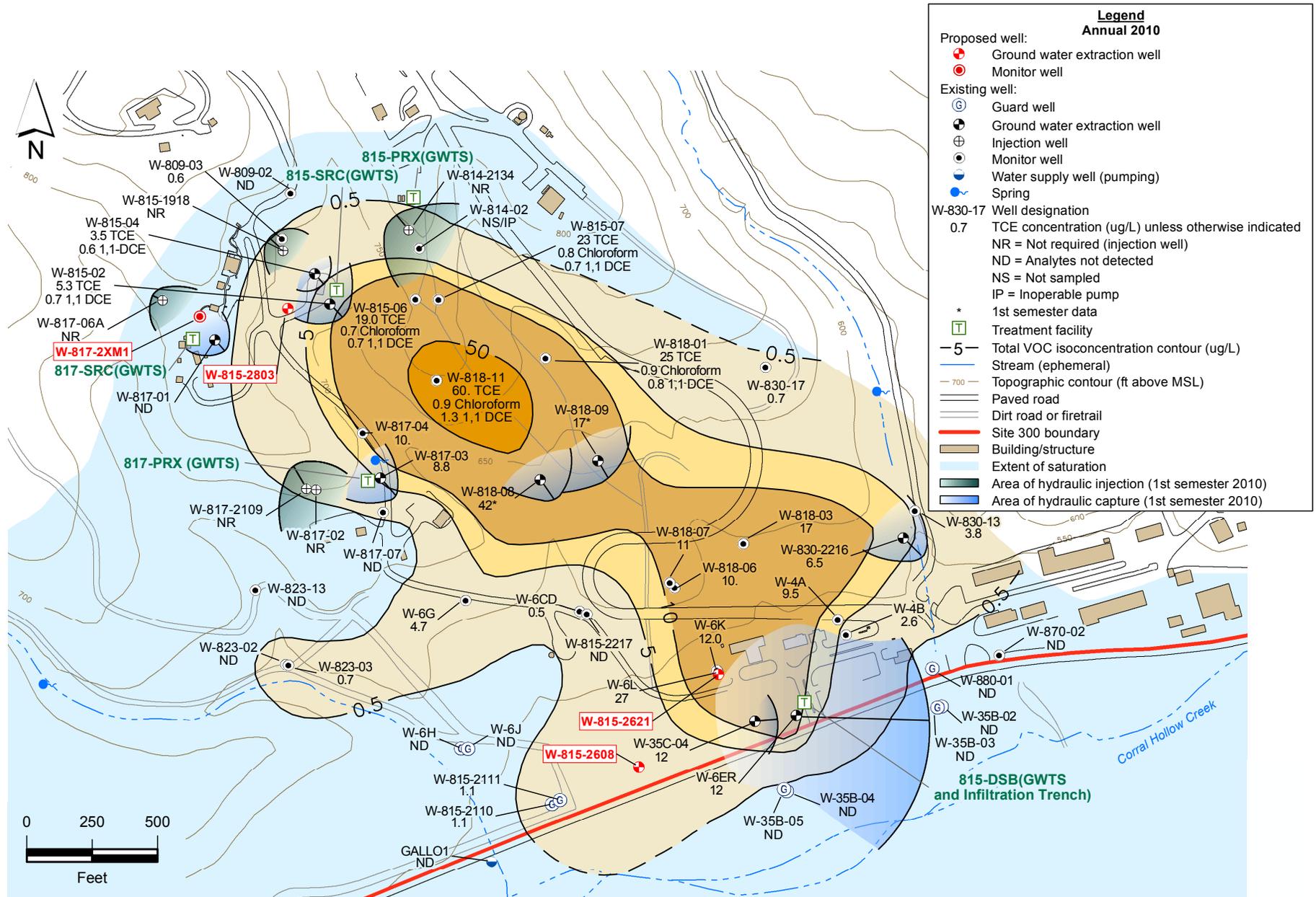
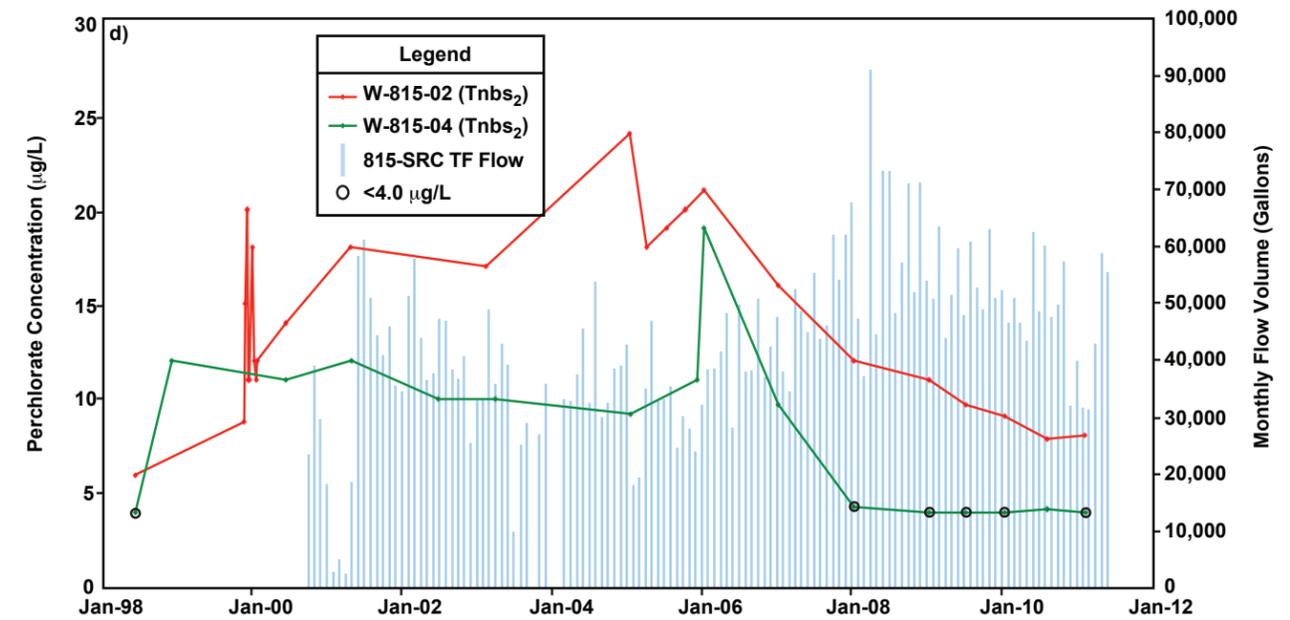
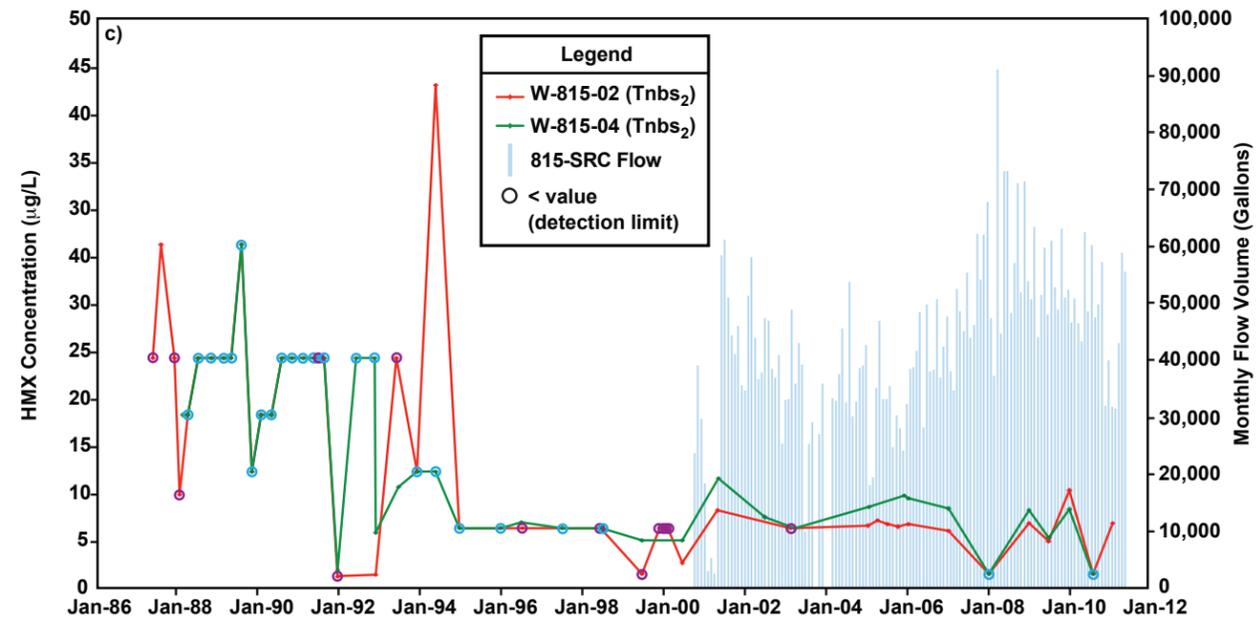
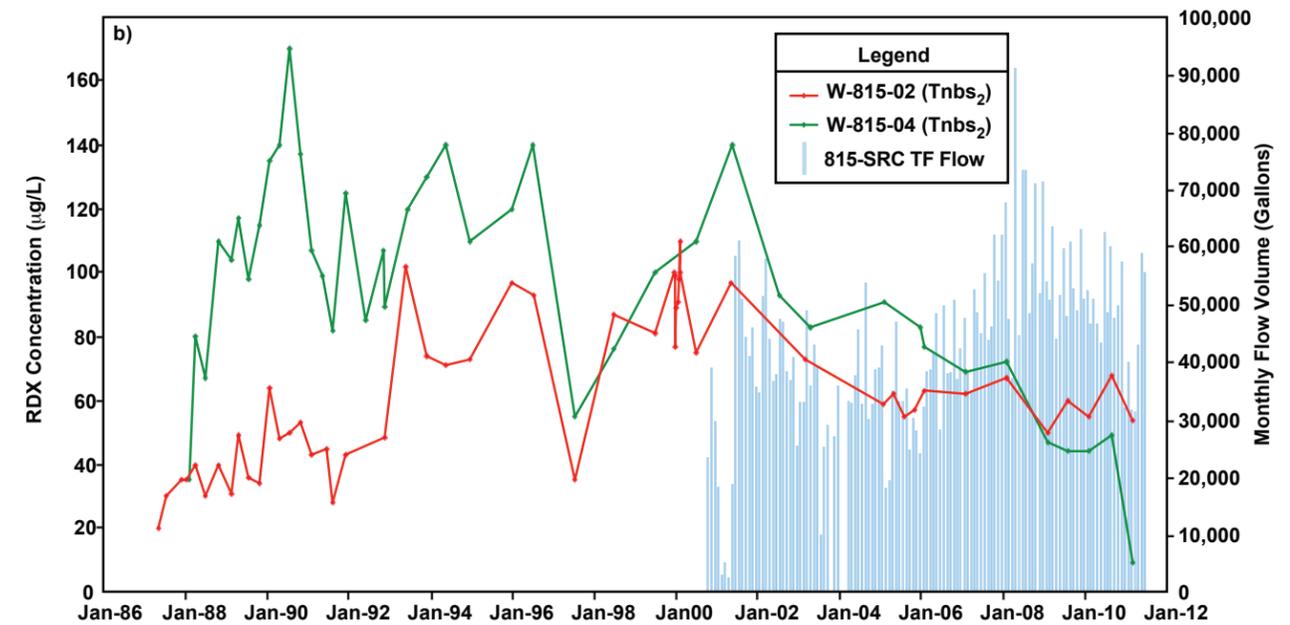
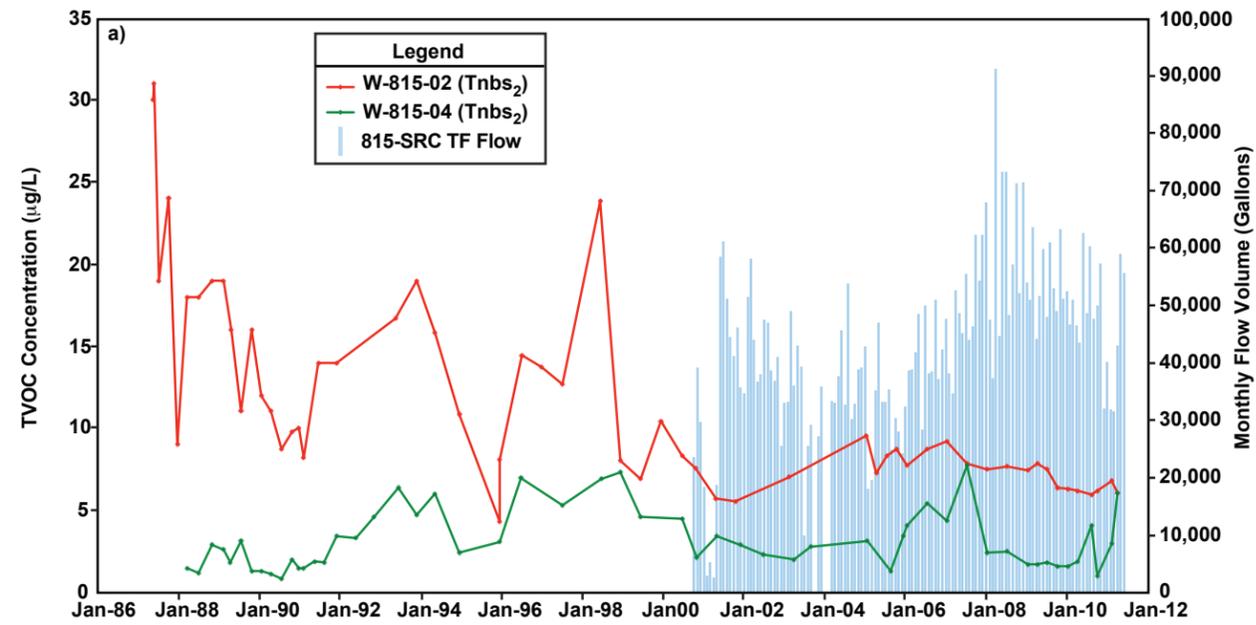


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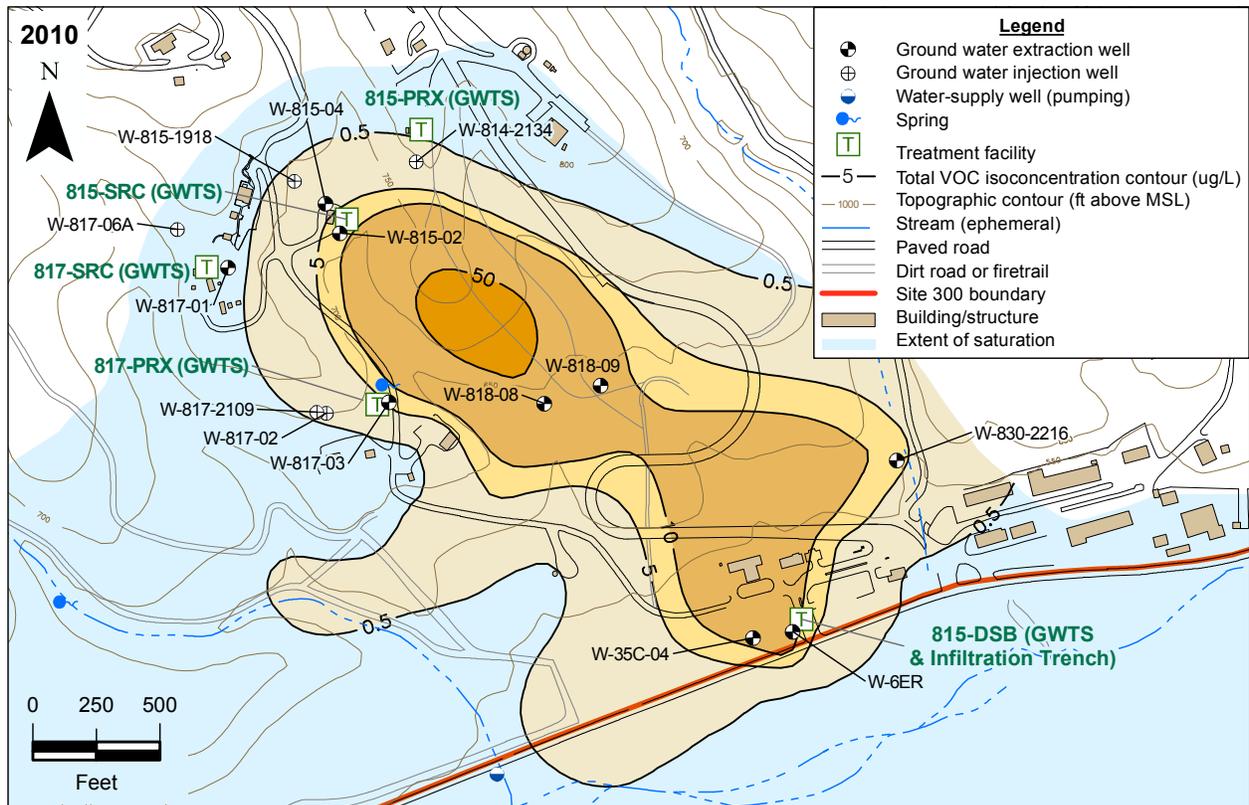
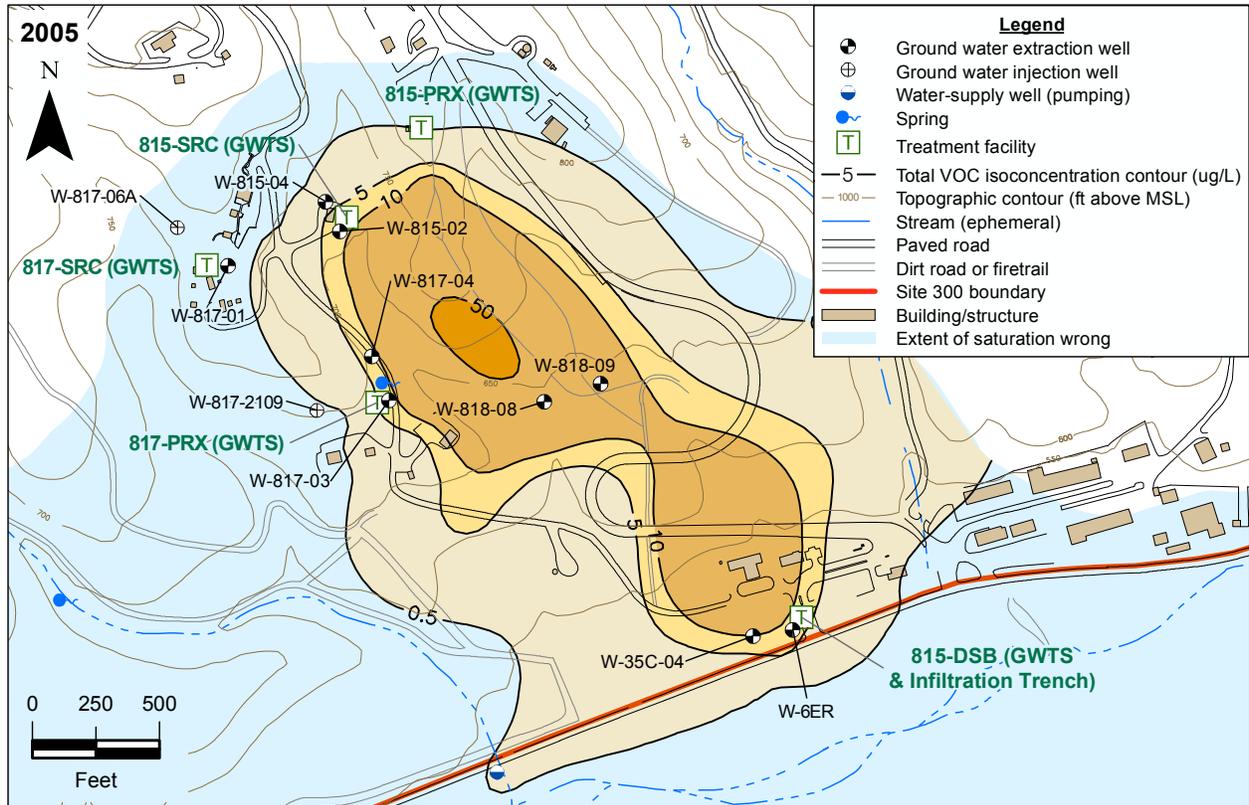
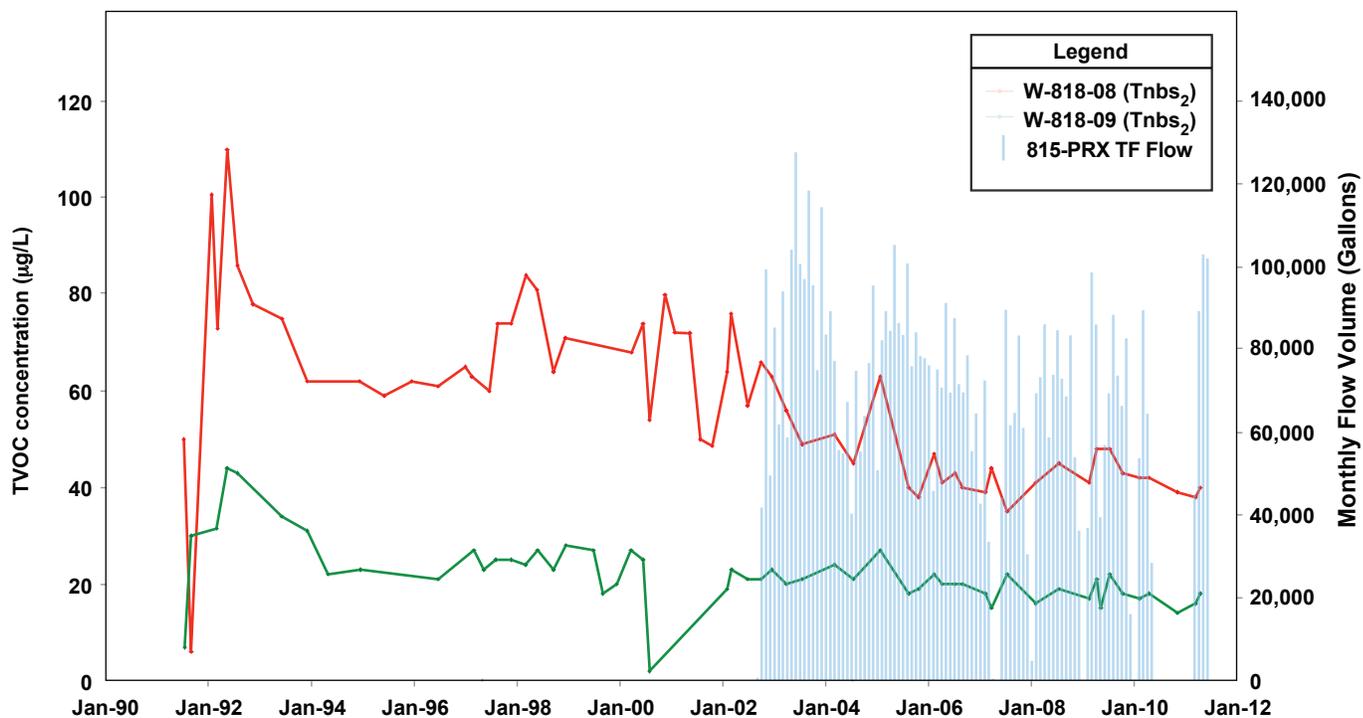
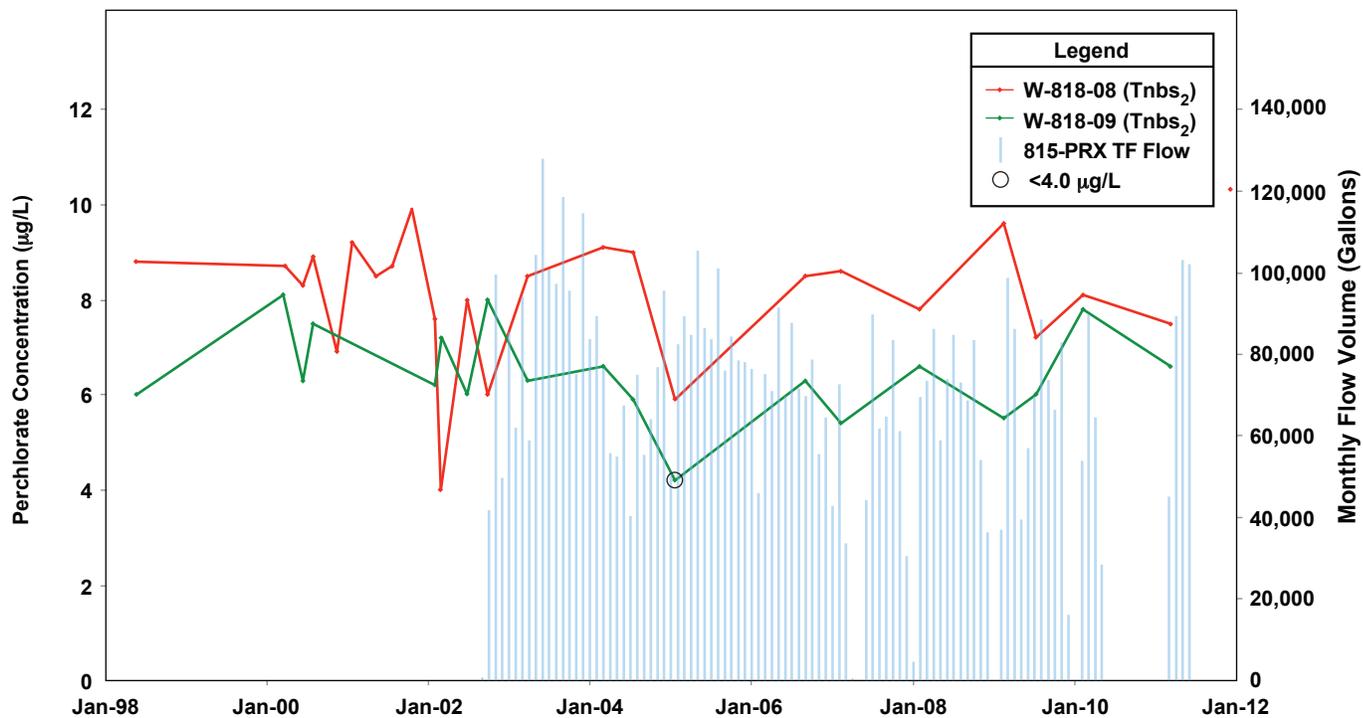


Figure 16. Comparison of the existing extraction wells and the distribution of total VOCs in ground water the Tnbs₂ hydrostratigraphic unit in the second semester 2005 and the second semester 2010.

a)

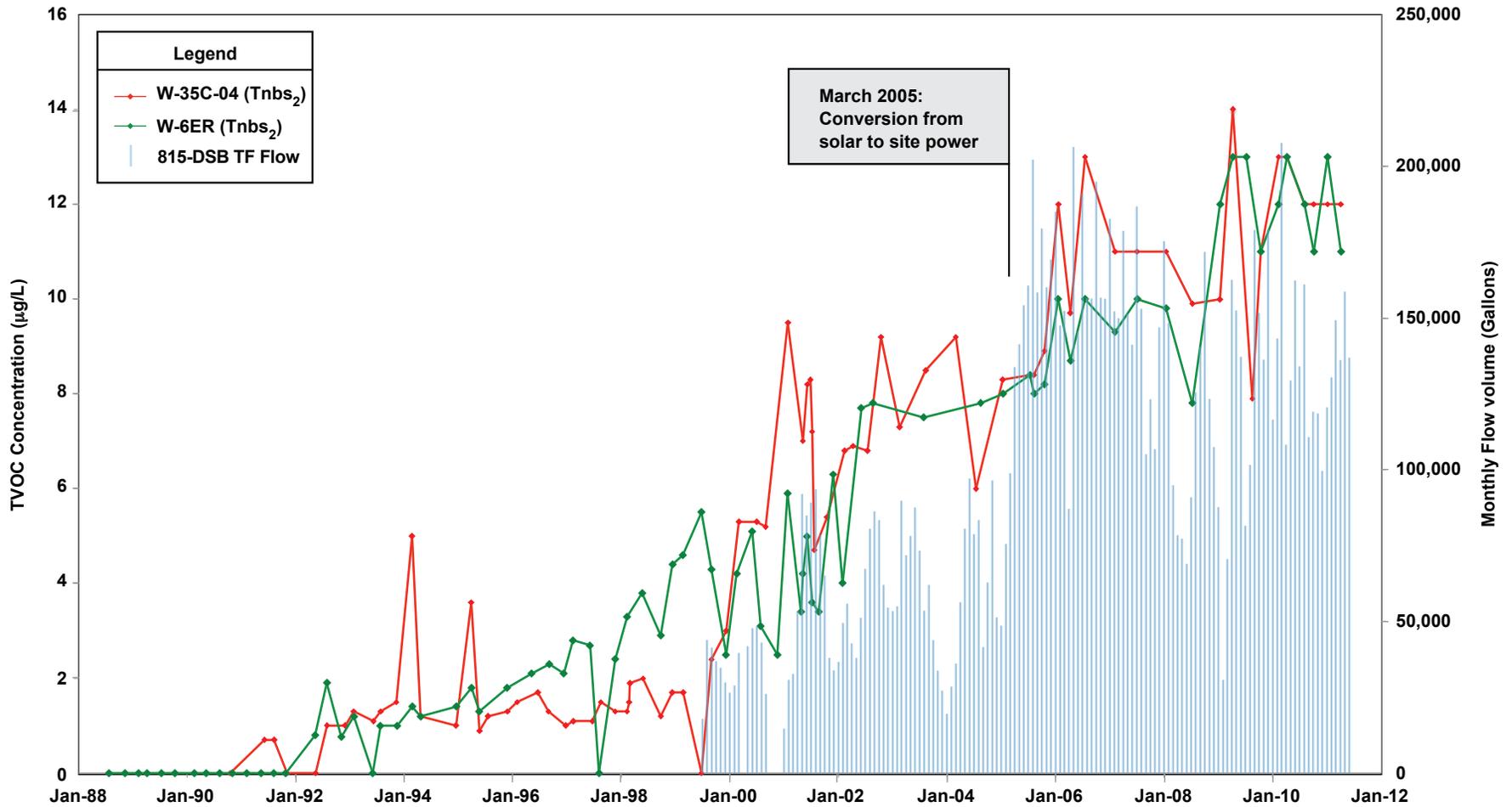


b)



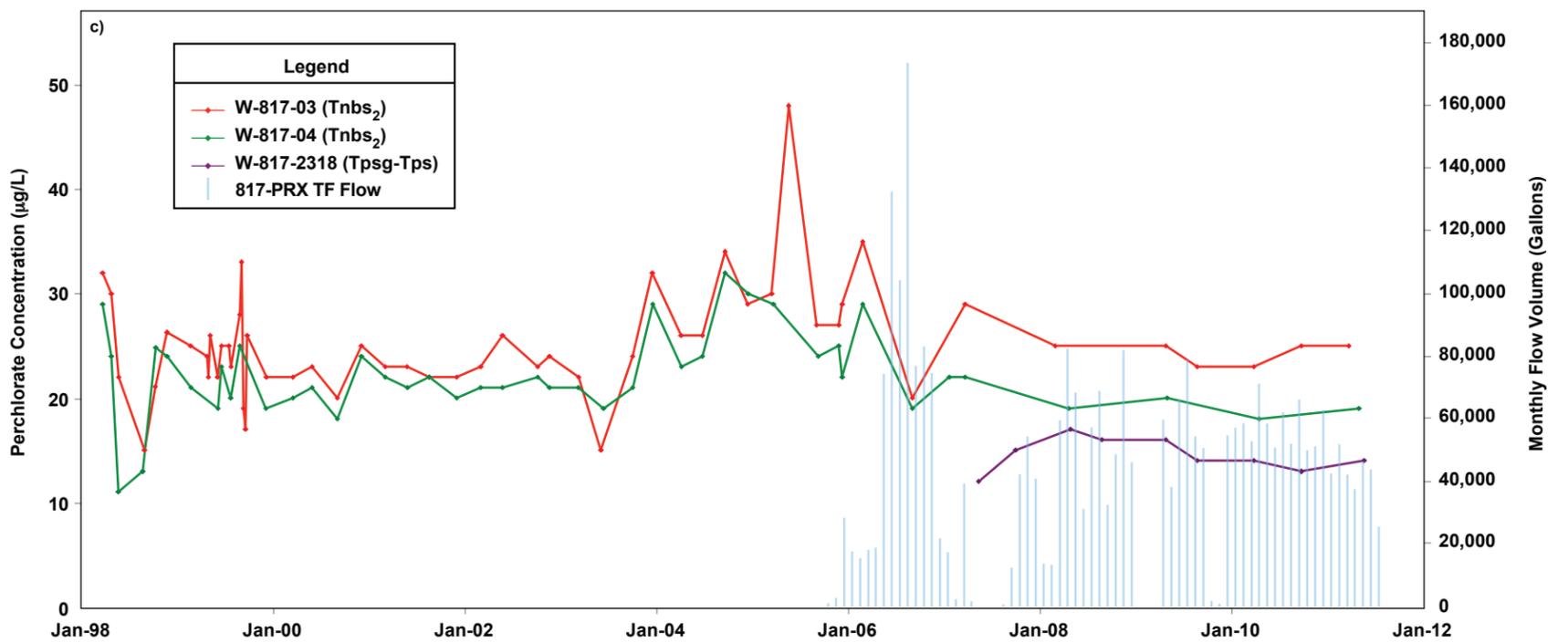
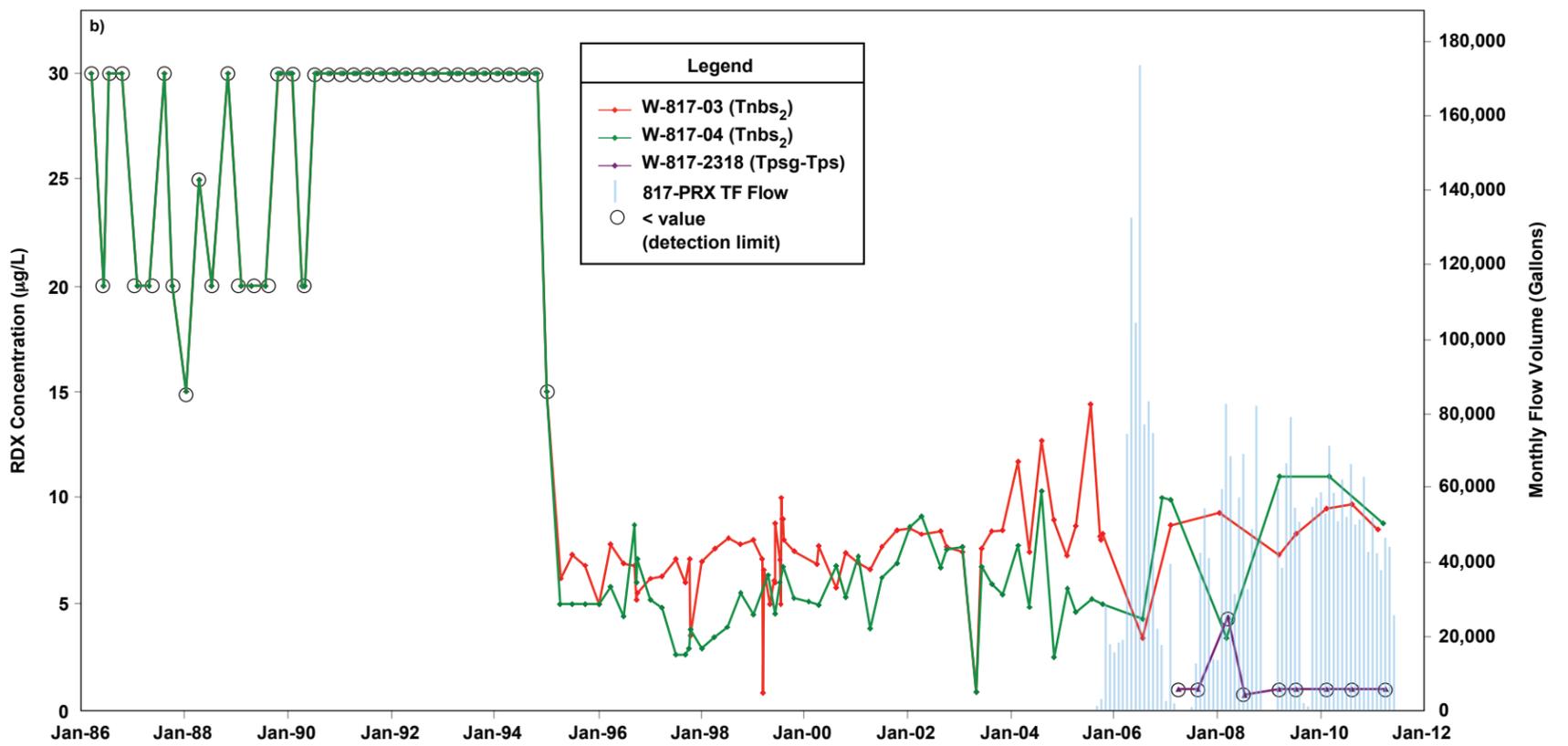
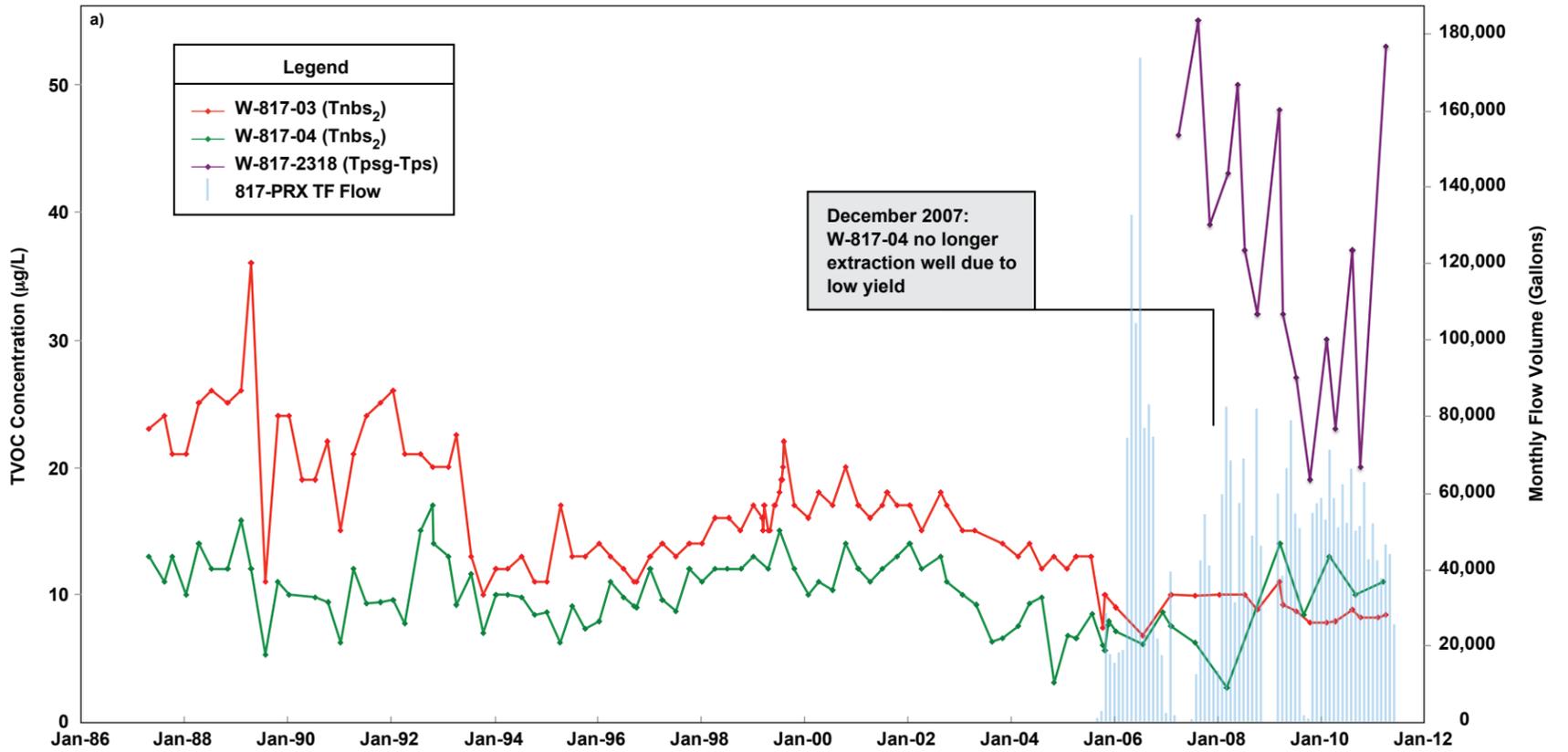
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Figure 17. Time-series plots of a) total VOCs, and b) perchlorate in ground water in the 6 i]X]b['815-Proximal Area extraction wells and monthly facility flow.



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Figure 18. Time-series plots of total VOCs in ground water in the Building 815-Distal Site Boundary Area extraction wells and monthly facility flow.



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Figure 19. Time-series plots of a) total VOCs, b) RDX, and c) perchlorate in ground water in the Building 817-Proximal Area extraction wells and monthly facility flow.

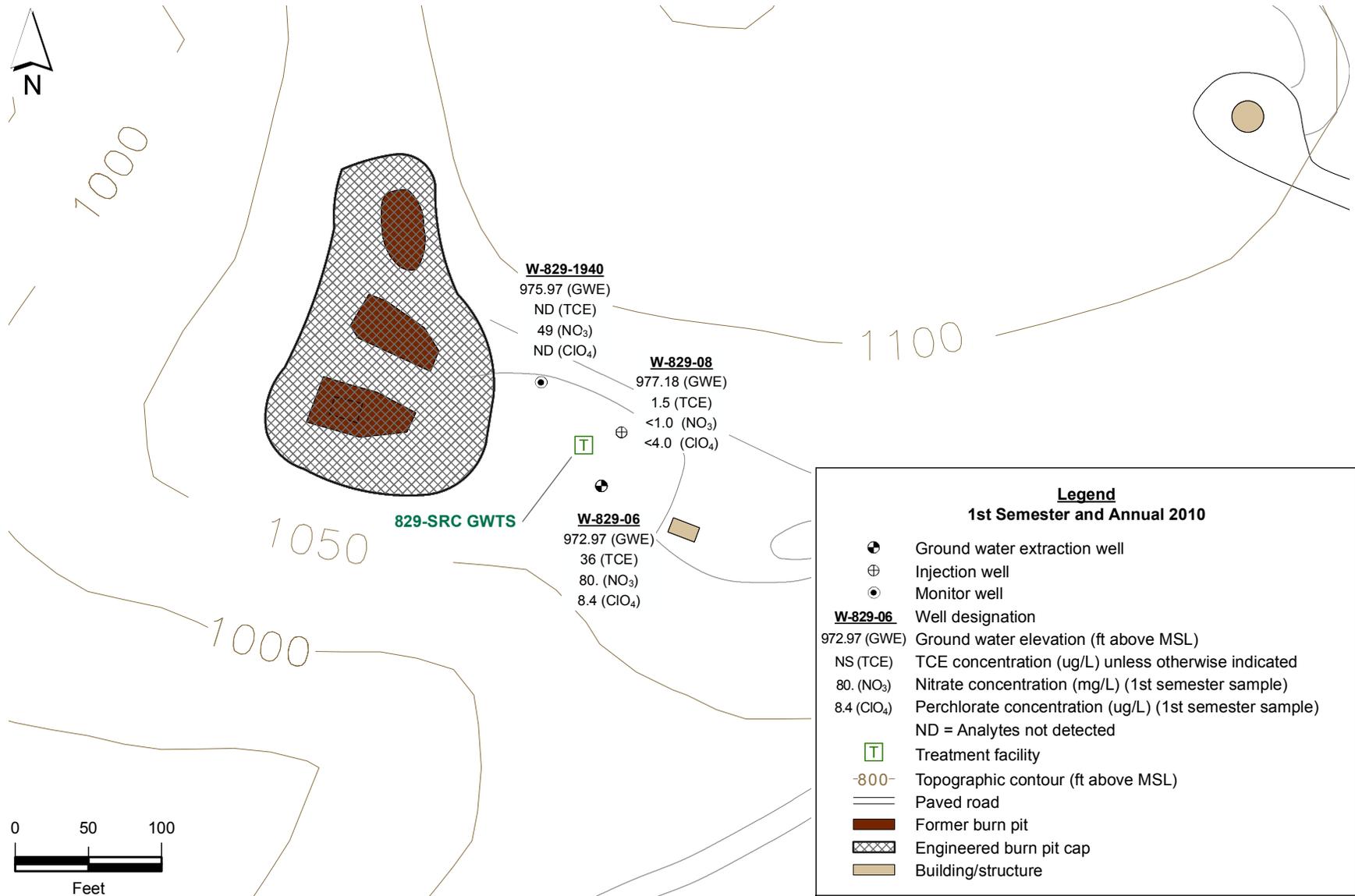
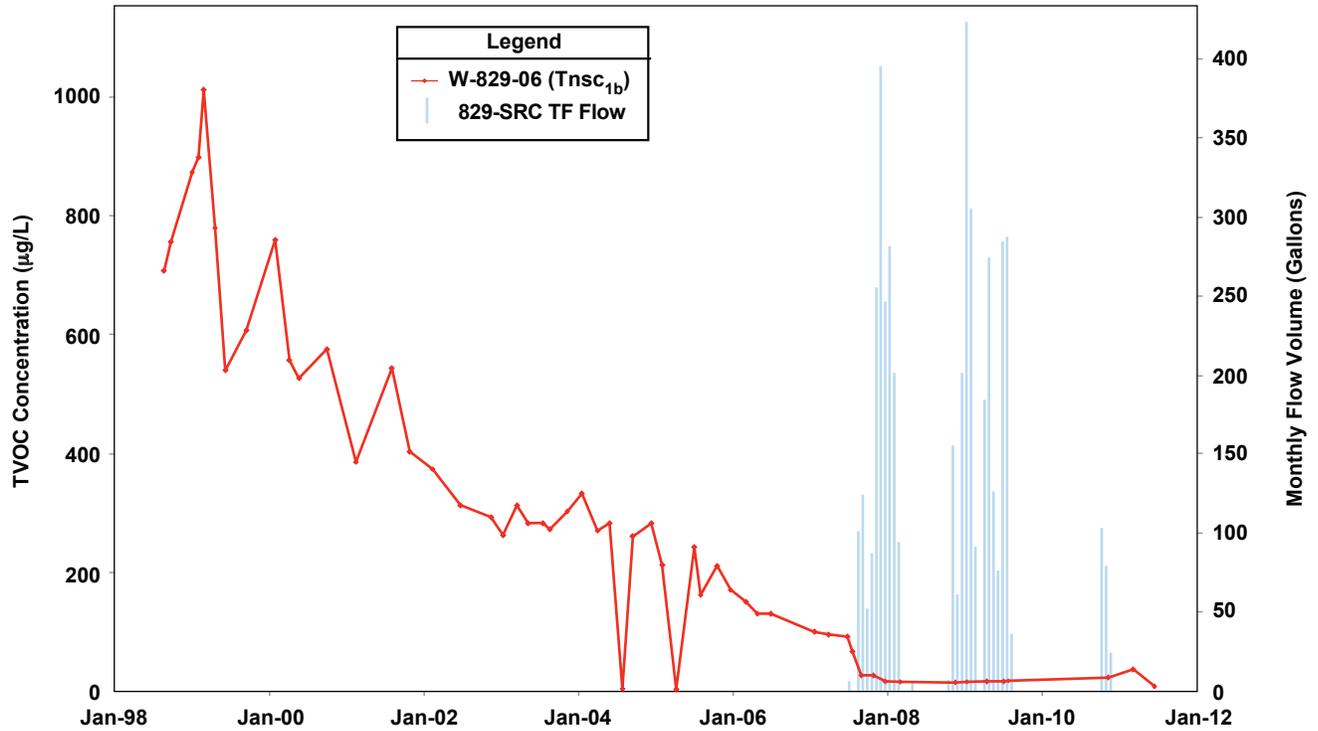
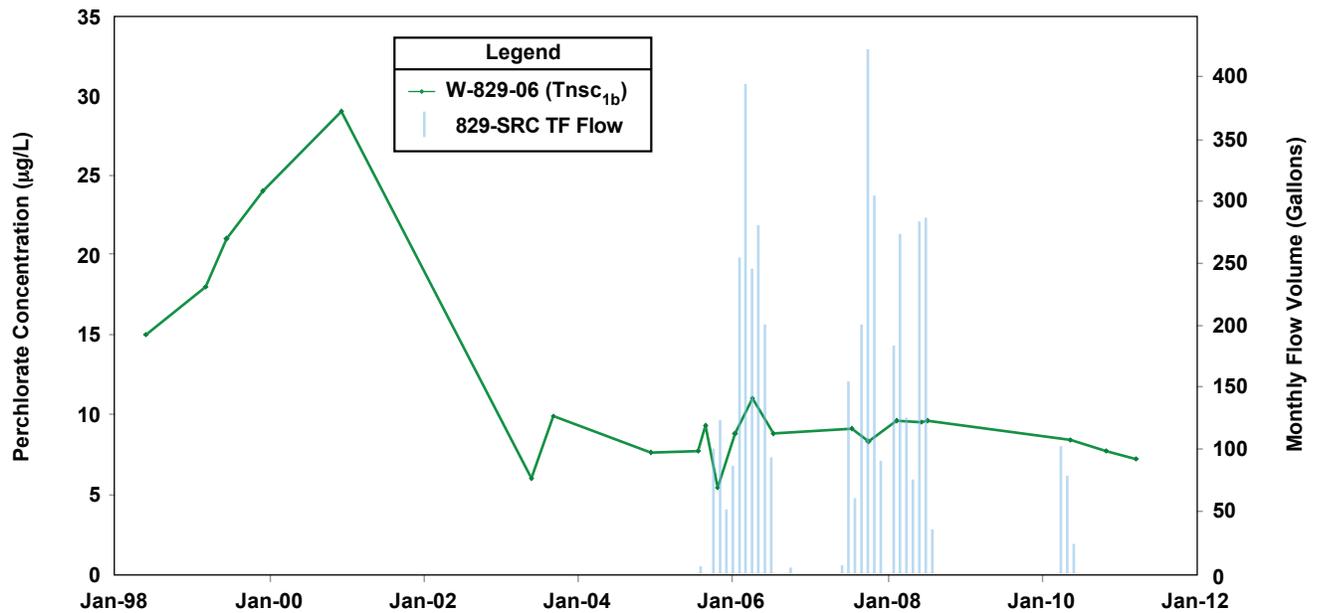


Figure 20. Building 829 burn pit map showing monitor, extraction and injection wells; ground water elevations; and total VOC, perchlorate, and nitrate concentrations for the Tnsc_{1b} hydrostratigraphic unit.

a)



b)



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Figure 21. Time-series plots of a) TVOCs, and b) perchlorate in ground water in the 6 i]X]b['829-Source Area extraction wells and monthly facility flow.

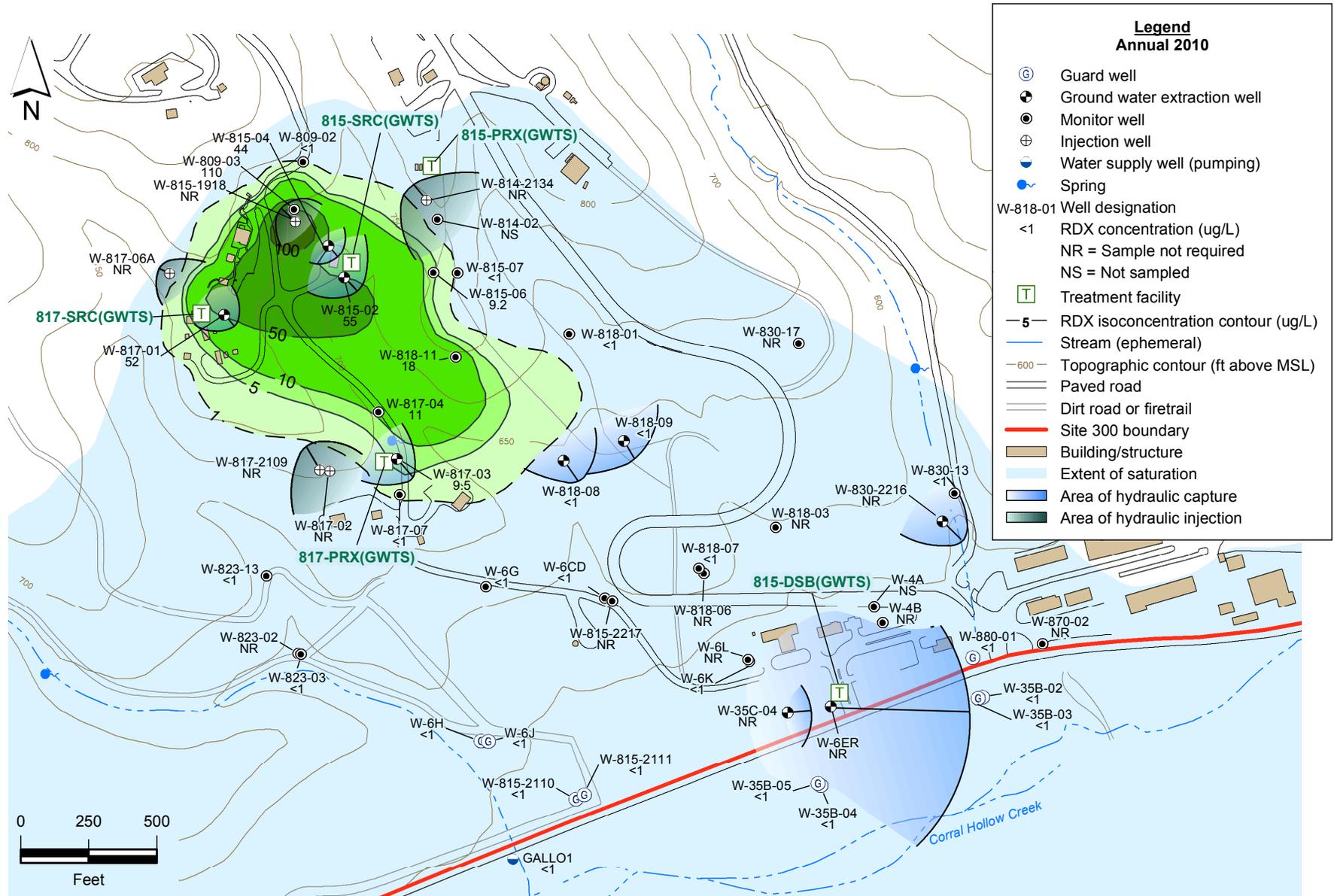


Figure 22. RDX isoconcentration contour map for the Tnbs₂ hydrostratigraphic unit.

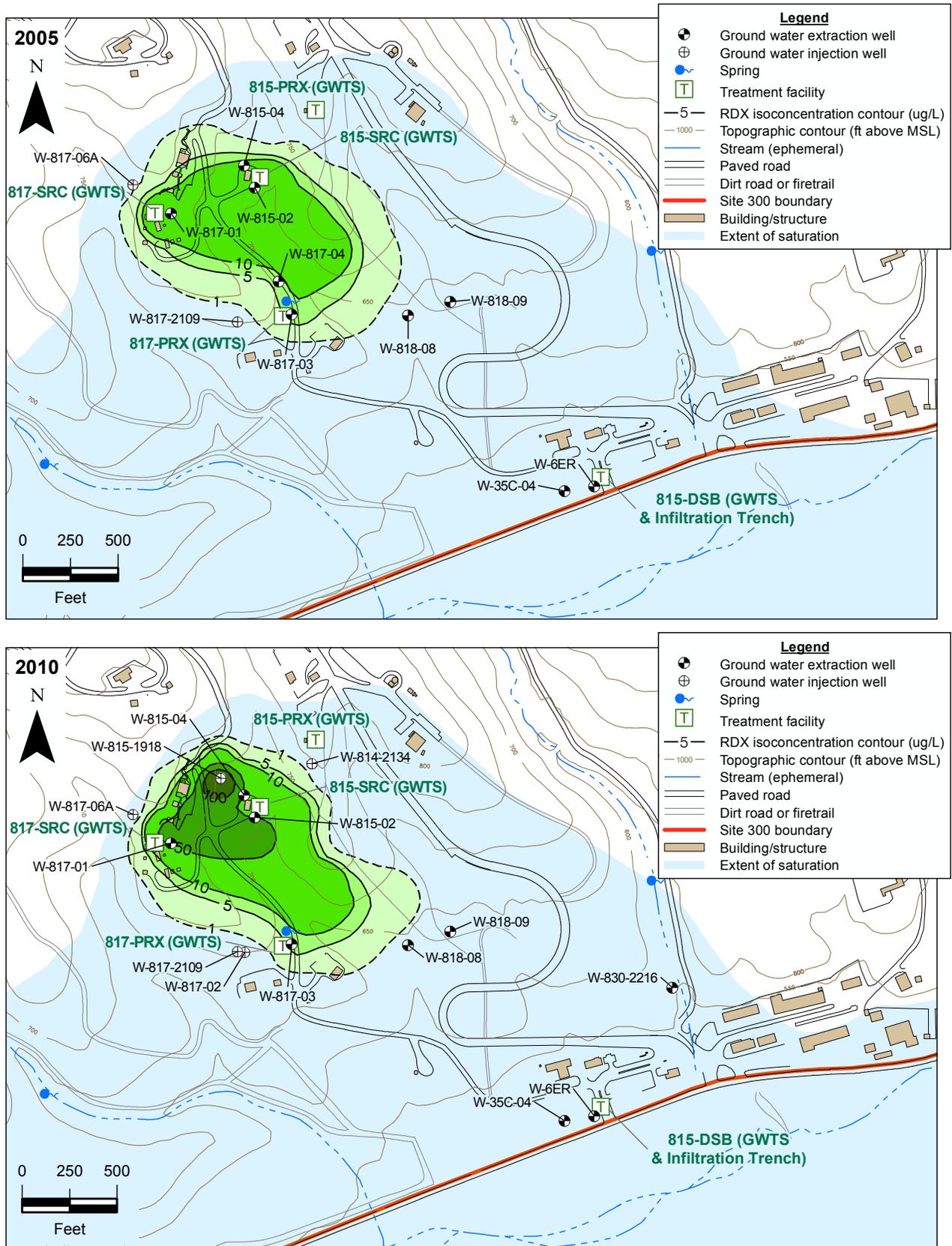
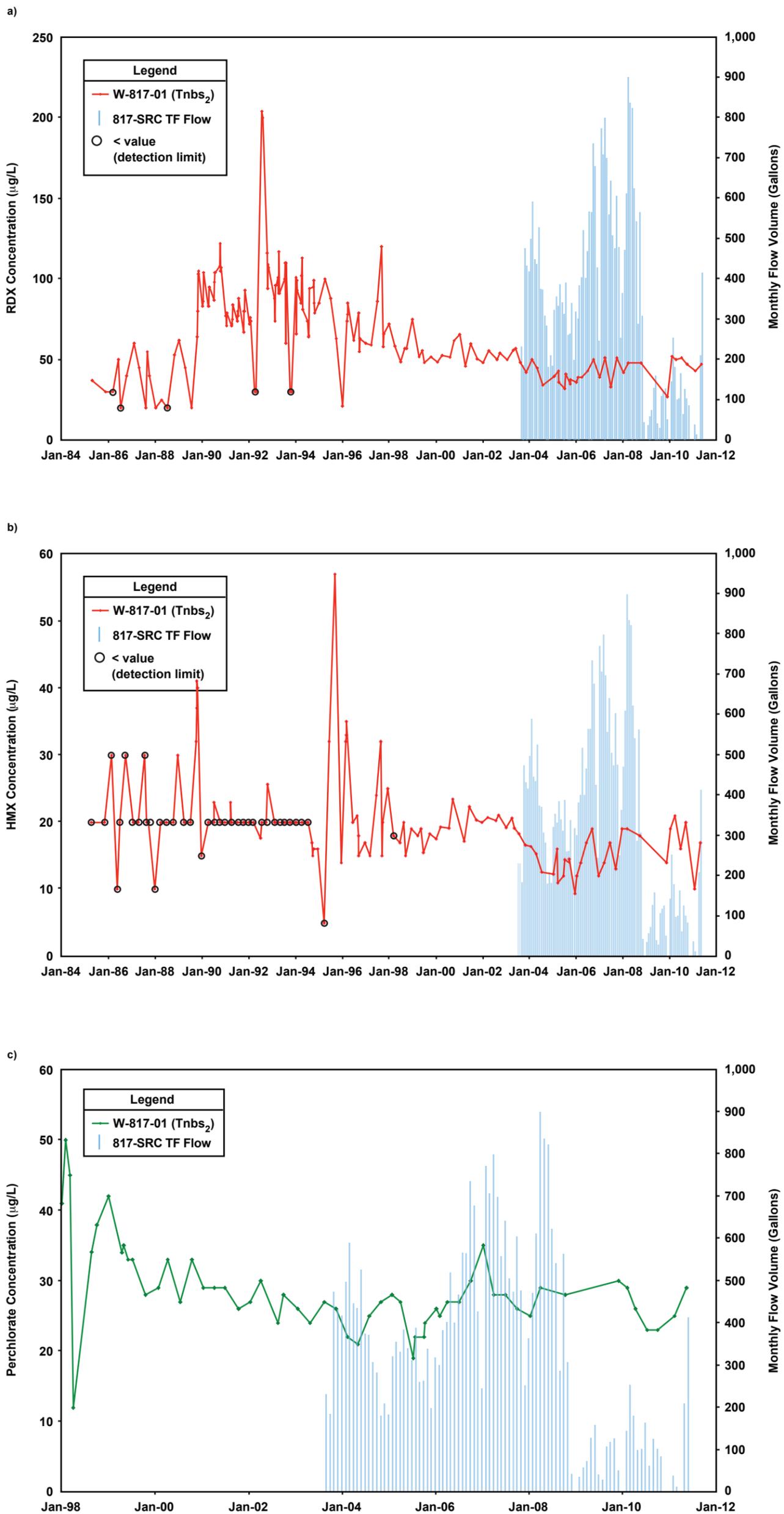


Figure 23. Comparison of the existing extraction wells and the distribution of RDX in ground water in the Tnbs₂ hydrostratigraphic unit in the first semester 2005 and the first semester 2010.



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Figure 24. Time-series plots of a) RDX, b) HMX, and c) perchlorate in ground water in the Building 817-Source Area extraction wells and monthly facility flow.

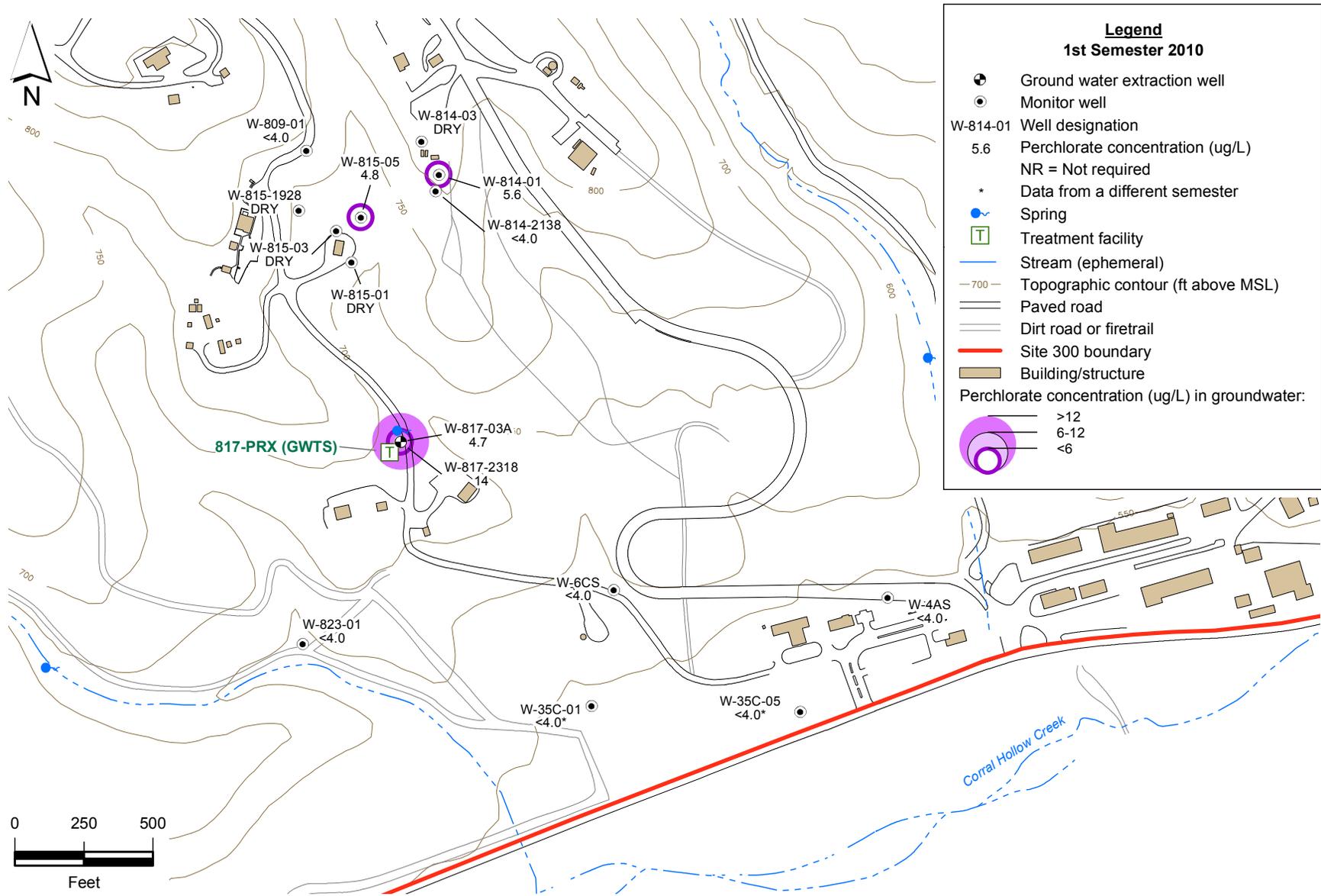


Figure 25. Map showing perchlorate concentrations for the Tpsg-Tps hydrostratigraphic unit.

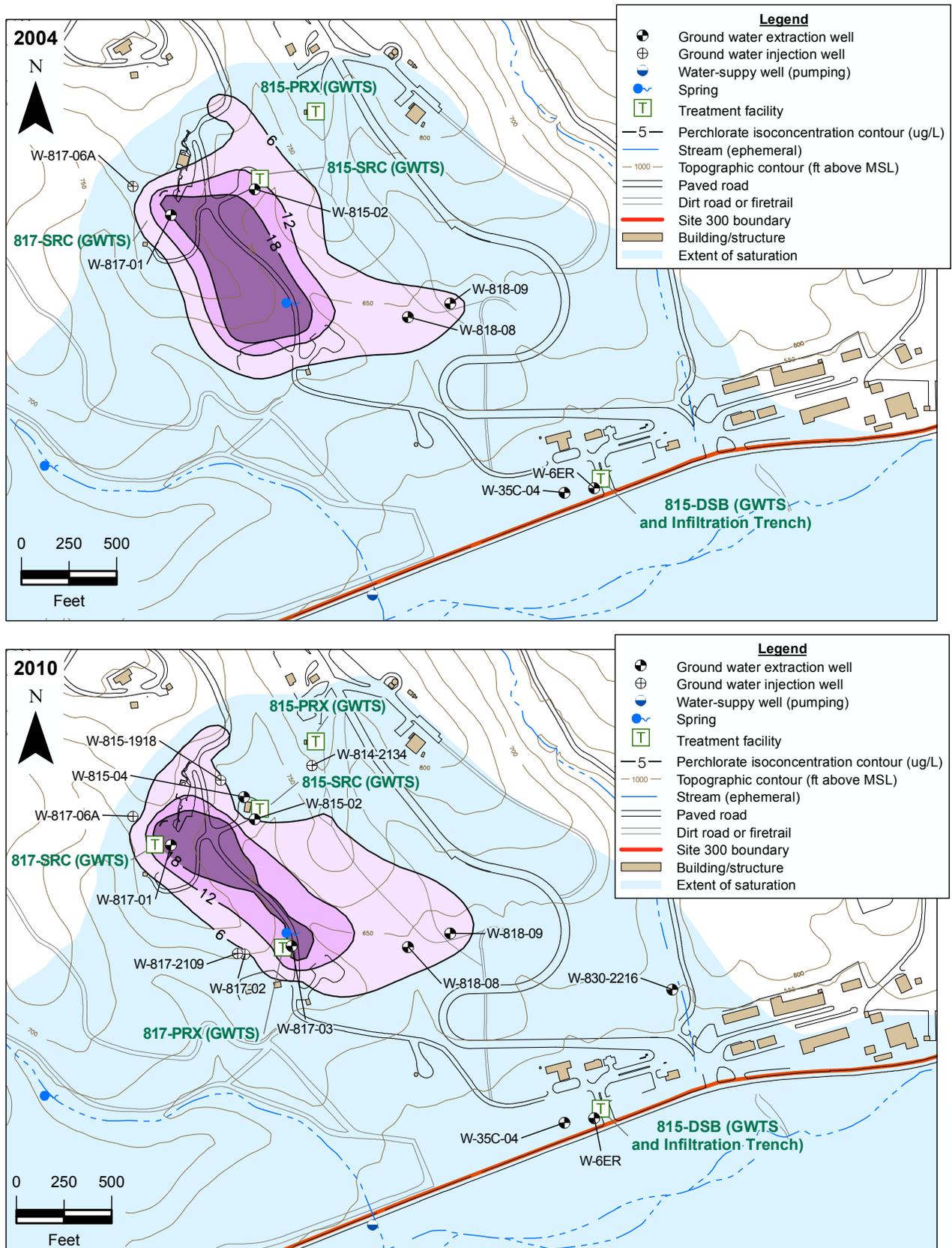


Figure 26. Comparison of the existing extraction wells and the distribution of perchlorate in ground water in the Tnbs₂ hydrostratigraphic unit in the second semester 2004 and the first semester 2010.

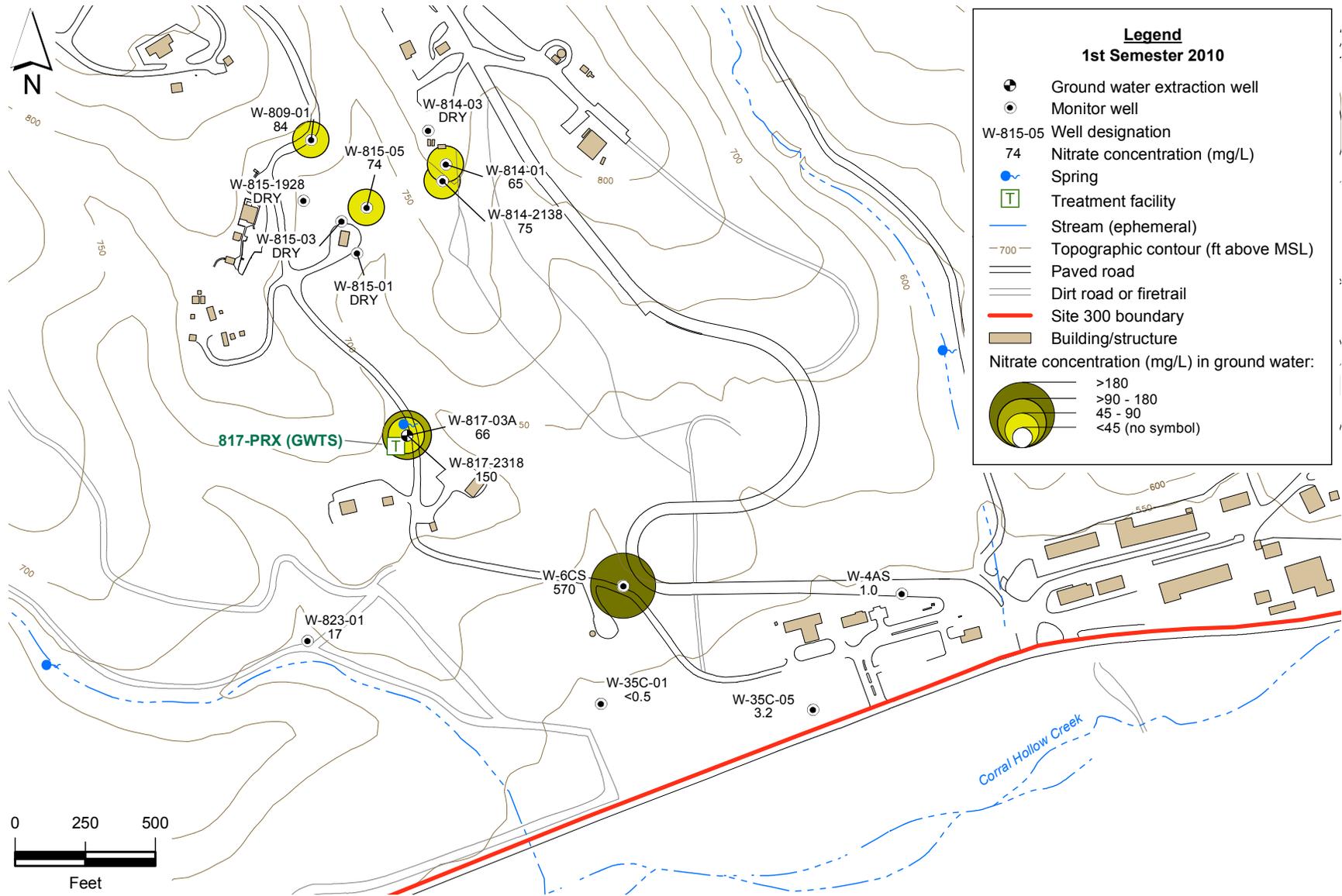


Figure 28. Map showing nitrate concentrations for the Tpsg-Tps hydrostratigraphic unit.

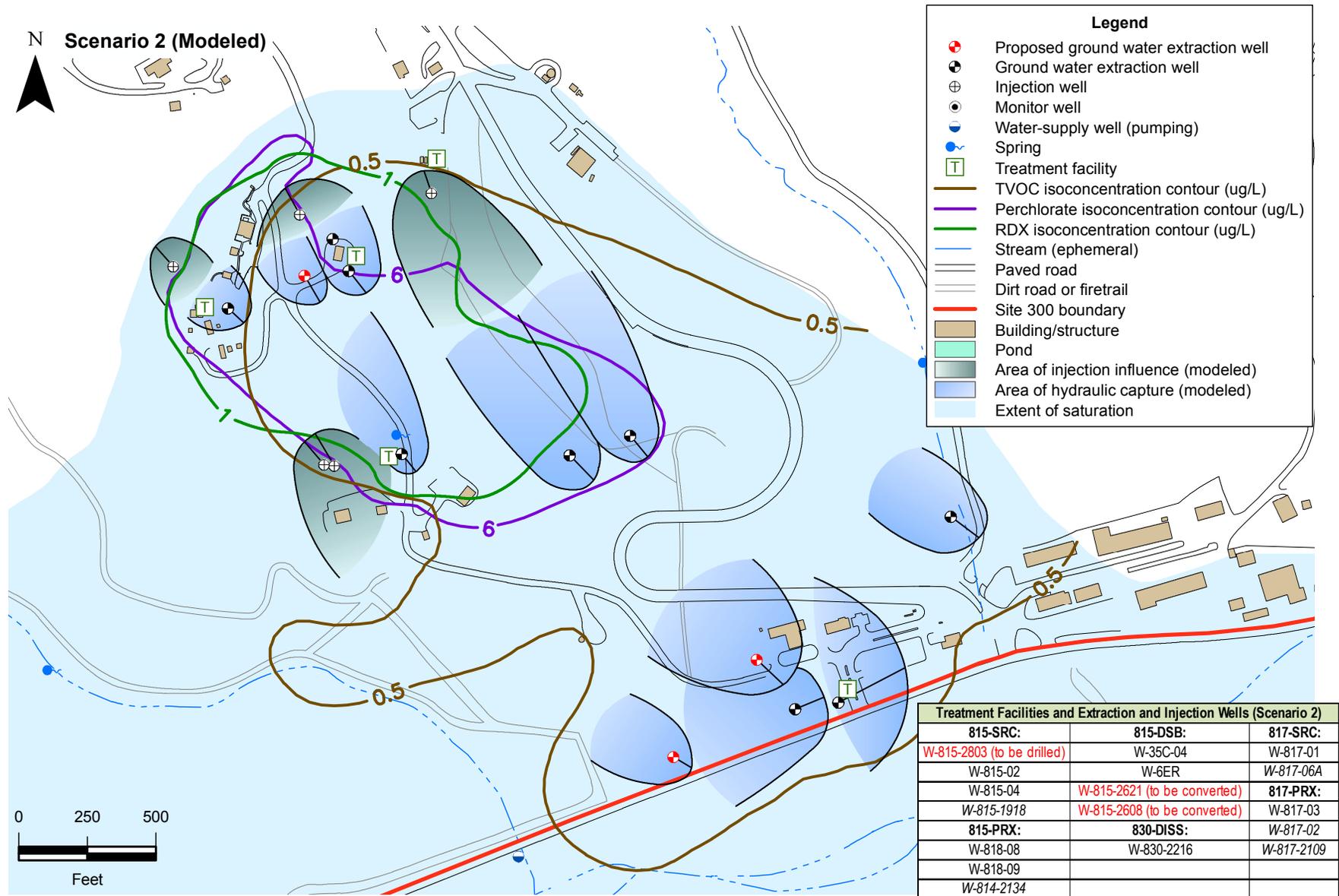


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- Table 4. Contaminants of Concern, Startup Dates, Extraction Wells, and Hydrostratigraphic Unit (HSU) Completion for the HEPA Ground Water Extraction and Treatment Systems.

Table 1. Actual annual costs for the High Explosives Process Area Operable Unit for fiscal years 2007 through 2011.

Fiscal Year	Annual Budget	Actual Annual Cost	Cost Variance
2007	\$922,808	\$759,748	\$163,060 ^a
2008	\$909,376	\$868,033	\$41,343 ^a
2009	\$1,140,609	\$927,495	\$213,114 ^b
2010	\$1,073,358	\$1,359,225	-\$285,867 ^b
2011	\$1,529,215	\$2,208,914	-\$679,699 ^c

Notes:

^a The High Explosives Process Area Operable Unit was under budget due to lower than expected operations, maintenance, and optimization costs.

^b Wells budgeted for 2009 were carried-over and installed in 2010.

^c The High Explosives Process Area Operable Unit was over budget during fiscal Year 2011 due to the Building 829-Source engineering assessment and upgrade and Building 815-Distal Site Boundary upgrade and pipeline expansion activities costing more than planned.

Table 2. Description of Land use (institutional and engineered) controls for the High Explosives Process Area Operable Unit.

Land use control performance objective and duration	Risk necessitating institutional/land use control	Land use controls and implementation mechanism
<p>Prevent water-supply use/consumption of contaminated groundwater until ground water cleanup standards are met.</p>	<p>VOCs, RDX, nitrate, and perchlorate concentrations in ground water exceeding drinking water standards.</p>	<p>There are two onsite water-supply wells in the HEPA Operable Unit (Wells 18 and 20). Contamination in HEPA ground water is contained in an aquifer that is 250 ft above, and hydraulically separated from the deeper, clean aquifer in which Well 20 is screened. While Well 18 is no longer used as a water supply well, it is a backup well for emergency fire suppression. Well 18 is cased through the contaminated aquifer. Therefore, onsite workers are not at risk from drinking contaminated water from Wells 18 and 20. Wells 18 and 20 are sampled monthly for contamination.</p> <p>Any proposed well drilling activities would be submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. Prohibitions on drilling water-supply wells in areas of ground water contamination will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.</p> <p>A VOC plume extends offsite above the drinking water standards. A water-supply well exists on the offsite property. To prevent offsite water-supply use/consumption of contaminated ground water, an MOU will be developed with the off-site property owner that provides point-of-use treatment should VOCs reach the water-supply well above cleanup standards. The MOU will also restrict the drilling of water-supply or agricultural wells within the plume until cleanup standards are met.</p>

Table 2. Description of Land use (institutional and engineered) controls for the High Explosives Process Area Operable Unit. (Continued)

Land use control performance objective and duration	Risk necessitating institutional/land use control	Land use controls and implementation mechanism
Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.	Potential exposure to VOCs, HMX, and RDX at depth in subsurface soil at the HEPA OU ^a .	All proposed excavation activities must be cleared through the LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, LLNL Hazards Control ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination.
Maintain land use restriction in the vicinity of Building 815 until annual risk re-evaluation indicates that the risk is less than 10^{-6} .	Pre-remediation risk of 5×10^{-6} for onsite workers from inhalation of VOCs volatilizing from the subsurface soil into outdoor air in the vicinity of Building 815.	This risk has been successfully mitigated since 2004 through ground water extraction and treatment, therefore this institutional/land use control is no longer needed.

Table 2. Description of Land use (institutional and engineered) controls for the High Explosives Process Area Operable Unit. (Continued)

Land use control performance objective and duration	Risk necessitating institutional/land use control	Land use controls and implementation mechanism
<p>Maintain land use restriction in the vicinity of Spring 5 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.</p>	<p>1×10^{-5} risk for onsite workers continuously inhaling VOC vapors volatilizing from Spring 5 into outdoor air over a 25-year period.</p>	<p>The spring has been dry since 2003. There are currently no active facilities located in the vicinity of the Spring 5 and there is no surface water present in the spring. Current activities in the vicinity of the Spring 5 are restricted to semi-annual spring sampling. The time spent sampling is well below the exposure scenario for which the unacceptable exposure risk was calculated, which assumed a worker would spend 8 hours a day, five days a week for 25 years working at Spring 5.</p> <p>DOE will conduct annual risk re-evaluations when water is present in Spring 5 to determine when the inhalation risk has been mitigated. The risk re-evaluation results will be reported in the Annual Site-Wide Compliance Monitoring Reports.</p> <p>Any significant changes in activities conducted in the Spring 5 area must be cleared through LLNL Work Induction Board. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants as a result of the proposed area usage. If a potential for contaminant exposure is identified as a result of these changes in activities or area use, LLNL Hazards Control is notified and determines any necessary personal protective equipment to prevent exposure.</p>
<p>Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.</p>	<p>Potential exposure to contaminated waste and/or environmental media.</p>	<p>The Site 300 Federal Facility Agreement contains provisions that assure that DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations, Division 4.5, Chapter 39, Section 67391.1.</p> <p>Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, DTSC, and the RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use. These restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document.</p>

Notes appear on the following page.

Table 2. Description of Land use (institutional and engineered) controls for the High Explosives Process Area Operable Unit. (Continued)

Notes:

DOE = United States Department of Energy.

DTSC = California Department of Toxic Substances Control.

U.S. EPA = United States Environmental Protection Agency.

HEPA = High Explosives Process Area.

HMX = High melting explosive.

LLNL = Lawrence Livermore National Laboratory.

RDX = Research department explosive.

RWQCB = California Regional Water Quality Control Board.

VOCs = Volatile organic compounds.

^a Risk for onsite worker exposure to VOCs, RDX, and HMX at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to VOCs, RDX, and HMX in subsurface soil during excavation conservatively assume that these COCs in subsurface soil may pose a risk to human health.

Table 3. Historical and current maximum concentrations of trichloroethene (TCE), Research Department Explosive (RDX), perchlorate, and nitrate by hydrostratigraphic unit (HSU) in the High Explosives Process Area Operable Unit compared to ground water cleanup standards.

HSU	Constituent	Historical Maximum			First Semester 2011 Maximum			Cleanup Standard
		Concentration	Sample Location	Sample Date	Concentration	Sample Location	Sample Date	
Tpsg-Tps	TCE	450 µg/L	W-815-01	May-92	53 µg/L	W-817-2318	Apr-11	5 µg/L
	RDX	350 µg/L	W-815-01	Mar-88	<1 µg/L	All wells	NA	1 µg/L
	Perchlorate	17 µg/L	W-817-2318	Mar-08	14 µg/L	W-817-2318	Apr-11	6 µg/L
	Nitrate ^a	160 mg/L	W-817-2318	Apr-11	160 mg/L	W-817-2318	Apr-11	45 mg/L
Tnbs ₂	TCE	110 µg/L	W-818-08	May-92	40 µg/L	W-818-08	Apr-11	5 µg/L
	RDX	204 µg/L	W-817-01	Jul-92	106 µg/L	W-809-03	Mar-11	1 µg/L
	Perchlorate	50 µg/L	W-817-01	Feb-98	29 µg/L	W-817-01	May-11	6 µg/L
	Nitrate	140 mg/L	W-809-02	Jan-11	100 mg/L	W-815-02 and W-815-04	Feb-11	45 mg/L
Tnsc _{1b}	TCE	1000 µg/L	W-829-06	Aug-93	8.1 µg/L	W-829-06	Mar-11	5 µg/L
	RDX	NA	NA	NA	NA	NA	NA	1 µg/L
	Perchlorate	29 µg/L	W-829-06	Dec-00	7.2 µg/L	W-829-06	Mar-11	6 µg/L
	Nitrate	240 mg/L	W-829-06	Dec-00	56 mg/L	W-829-06	Mar-11	45 mg/L

Notes:

mg/L = Milligrams per liter.

NA = Not applicable.

µg/L = Micrograms per liter.

^a Excluding near sheep ranch well W-6CS.

Table 4. Contaminants of Concern, Startup Dates, Extraction Wells, and Hydrostratigraphic Unit (HSU) Completion for the HEPA Ground Water Extraction and Treatment Systems.

Treatment Facility	Contaminants of Concern (COCs)	Year of Facility Startup	Existing Extraction Wells	HSU	Proposed New Extraction Wells (EW) and Monitor Wells (MW)
815-SRC	VOCs	September-00	W-815-02, W-815-04	Tnbs ₂	Tnbs ₂ EW: W-815-2803
	HE compounds				
	Perchlorate				
	Nitrate (as NO ₃) ^a				
815-PRX	VOCs	October-02	W-818-08, W-818-09	Tnbs ₂	None
	Perchlorate				
	Nitrate (as NO ₃) ^a				
815-DSB	VOCs	September-99	W-35C-04, W-6ER	Tnbs ₂	Tnbs ₂ EWs: W-815-2803, -2621 Tpsg-Tps MW: W-815-2XM1
817-SRC	HE compounds	September-03	W-817-01	Tnbs ₂	Tnbs ₂ MW: W-817-2XM1
	Perchlorate				
	Nitrate (as NO ₃) ^a				
817-PRX	VOCs	September-05	W-817-03, W-817-04; W-817-2318	Tnbs ₂ Tpsg-Tps	None
	HE compounds				
	Perchlorate				
	Nitrate (as NO ₃) ^a				
829-SRC	VOCs	August-05	W-829-06	Tnsc _{1b}	None
	Perchlorate				
	Nitrate (as NO ₃)				

Notes appear on the following page.

Table 4. Contaminants of Concern, Startup Dates, Extraction Wells, and Hydrostratigraphic Unit (HSU) Completion for the HEPA Ground Water Extraction and Treatment Systems. (Continued)

Notes:**HE = High explosives.****HSU = Hydrostratigraphic unit.****VOCs = Volatile organic compounds.****^a Nitrate-bearing water is reinjected to the subsurface to naturally attenuate through microbial denitrification, following treatment to remove other contaminants of concern.**

Appendix A

Ground Water Flow and Contaminant Transport Modeling in the Tnbs₂ Hydrostratigraphic Unit

Appendix A

Ground Water Flow and Contaminant Transport Modeling in the Tnbs₂ Hydrostratigraphic Unit

A-1. Objective

The primary objective of the ground water flow and contaminant transport modeling was to estimate capture zones in the Tnbs₂ Hydrostratigraphic Unit (HSU) based on two scenarios: 1) the existing extraction wellfield and 2) the "As Designed" expanded extraction wellfield. The model was also used to develop preliminary estimates of the time required to achieve cleanup standards within the Tnbs₂ HSU using the Scenario 2, "As Designed" extraction wellfield. In addition, the model serves as a framework for organizing field and laboratory data and provides a decision-making tool that can be used to refine DOE/LLNL's understanding of groundwater flow and contaminant transport within the High Explosives Process Area (HEPA) Operable Unit (OU). The model was used to simulate the transport of trichloroethene (TCE), a primary contaminant of concern (COC) in the HEPA OU, and Research Department Explosive (RDX) and perchlorate, two secondary COCs.

A-2. Conceptual Model

The Tnbs₂ HSU model simulated single-phase (saturated-zone) ground water flow within a single HSU. The Tnbs₂ HSU was modeled as a confined aquifer, although actual field conditions vary from unconfined to confined. This assumption of confined aquifer conditions is common and provides a reasonable approximation of field conditions without adding unnecessary complexity in the initial stages of model development. The conceptual model of flow and transport within the Tnbs₂ HSU is described in Section 3 (Background) of this report.

The following assumptions apply:

- The model was built by discretizing a single layer into three dimensions; however, due to vertically averaged properties, it is representative of a two-dimensional domain.
- The model solves for steady-state ground water flow and transient transport.
- The Tnbs₂ HSU is homogeneous and isotropic within distinct zones.
- TCE, RDX and perchlorate were the only chemical species modeled.
- Retardation effects were considered.
- Flow and transport occur only through porous media. Fracture flow is ignored.
- Biological effects are assumed negligible.
- Model is isothermal.

A-3. Model Description

A-3.1. Numerical Code

All modeling was conducted using FEFLOW, a Finite Element subsurface FLOW and transport simulation system developed at the Institute for Water Resources Planning and Systems Research, Ltd. (Diersch, 1998). Version 4.8, which was used for the simulations, features an interactive graphical interface and PEST, an add-in module for automated parameter estimation. Details about the equations governing ground water flow and contaminant transport are included in FEFLOW's reference manual (Diersch, 1998).

A-3.2. Model Domain and Grid

Figure A-1 shows the domain developed for the Tnbs₂ HSU FEFLOW model. The northern, eastern, and western boundaries of the model domains were chosen to approximately outline the lateral extent of saturation within the Tnbs₂ HSU. The southern boundary extends past the site boundary and Corral Hollow Road to include data from offsite wells. The initial model domain for the Tnbs₂ HSU had 38,144 elements and 29,151 nodes, and covered approximately 229 acres. The irregular, finite element mesh was created using FEFLOW's automated mesh generation program. The mesh was refined near the source areas to minimize problems with numerical dispersion during the transport calibration. Figure A-2 shows a three-dimensional visualization of the grid used for the model. The Tnbs₂ HSU was modeled as a separate 3-dimensional layer. Mass balances were checked after the flow and transport calibration to confirm that the mesh was adequately refined.

A-3.3. Boundary Conditions, Aquifer Type, Top and Bottom Layers

Boundary conditions were selected based on an analysis of expected recharge to and discharge from, the Tnbs₂ HSU. Recharge to the model was primarily along the northern boundary and through areal recharge. The northern boundary represents inflow from the catchment area where the Tnbs₂ stratigraphic units are exposed at the surface and from where narrow canyons intersect with the model boundaries. Areal recharge was applied in the northernmost, unconfined portions of the aquifer. Discharge was expected to occur along the southeastern border of the model where the Tnbs₂ HSU sub-crops beneath the Quaternary alluvium HSU and an upward gradient is present. Boundary conditions for the model are shown on Figure A-1. Boundaries with a net influx of groundwater are shown in red and discharge boundaries are shown in blue. Offsite water supply well Gallo1 was set a constant extraction flow rate of 1 gallon per minute (gpm) in some scenarios. This well is typically operated intermittently at higher flow rates; however, a conservative average extraction flow rate was selected to be consistent with long-term observed ground water elevations.

Recharge and discharge model boundaries were initially set as constant head based on ground water elevation data, and revised as appropriate during the flow calibration (see Section A-3.5). The top boundary conditions of the model represent areal recharge in the unconfined portions of the aquifer. Bottom boundaries of the model were no flow, and the surfaces used to create these layers were imported from a 3-dimensional (3-D) geologic model specifically developed for the southeast corner of Site 300. Boundary conditions have a considerable impact on ground water elevation and plume migration patterns.

A-3.4. Input Parameters

A-3.4.1. Flow Model Input Parameters

Hydraulic conductivity is important in determining boundary fluxes, water levels, and plume migration patterns. For the Tnbs₂ HSU, hydraulic conductivity for the calibrated model was approximately 0.8 feet per day (ft/day) throughout most of the domain and 0.4 ft/day in a 250-foot-wide fault zone located perpendicular to Route 3 and north of Building 823 (Figure A-1). Hydraulic conductivity within the aquifer was calibrated as described in Section A-3.5.1. A uniform hydraulic conductivity (K) (uniform within discrete zones) was used to better match the observed ground water elevation data and to match the lower yields observed near the fault zone. Hydraulic conductivities used to model the Tnbs₂ HSU in the Final Site-Wide Remediation Evaluation Summary Report for LLNL Site 300 (SWRSR) (Ferry et al., 2006) were 0.68 ft/day in the primary domain and 0.31 ft/day in the fault zone.

A-3.4.2. Transport Model Input Parameters

A porosity value of 0.32 was chosen using average core porosity measured during laboratory testing (Madrid and Jakub, 1998). Initial concentrations of TCE, RDX and perchlorate used for production runs were based on Annual 2010 Compliance Monitoring Report (Dibley et al., 2011) data. Concentrations were entered into FEFLOW at discrete points, and the program's linear interpolation scheme was used to assign values between data points. Minor adjustments were also made to ensure that the maximum concentrations in the initial concentration array matched the observed data. Values of less than 1 microgram per liter ($\mu\text{g/L}$) of a contaminant were set to a very low value to minimize problems with numerical dispersion during initial time steps. Plume migration patterns are affected by the values of longitudinal and transverse dispersivities. A longitudinal dispersivity of 10 feet (ft) and a transverse dispersivity of 1 ft, or 10% of the longitudinal dispersivity, were used for the cleanup time simulations. Both the longitudinal and transverse dispersivities were calibrated as part of the transport calibration process.

A-3.5. Calibration

A-3.5.1. Flow Calibration

The Tnbs₂ HSU FEFLOW model was calibrated using FEFLOW's automated parameter estimation tool (PEST), which minimized the sum of the squared differences between measured and modeled head data at multiple observation wells located within the model domain. The initial hydraulic conductivities input entered into PEST were 1 ft/day for the primary model domain and 0.1 ft/day for the fault zone. This range matched the values used to model the Tnbs₂ HSU in the SWRSR. Calibrated values as shown on Figure A-1 ranged from 0.4 to 0.8 ft/day. After initial calibration with PEST, minor (< 2 ft) adjustments in the initial specified head data used as boundary conditions were made to improve calibration results. The resulting ground water elevation maps were also subject to visual inspection to confirm the direction of the flow gradient. Recharge to the model of 2,498 cubic feet per day (cfd) through the northern boundary and via areal recharge was compared with independent estimates of recharge from 925 to 3,655 cfd that were determined considering the size of the catchment area (Pelmulder and Maxwell, 1997).

Figure A-3 shows a comparison between 1999 measured and modeled ground water elevation data. Ground water elevation data collected in 1999 were used for the initial

calibration. A steady-state pumping rate of 1 gallon per minute (gpm) at offsite water-supply well Gallo1 was assumed. The flow model was calibrated by comparing measured and modeled ground water elevation during a number of stressed and unstressed periods including 1999, 2005, 2006 and 2007. For each time period, the calibration was evaluated by visually comparing the measured and modeled data and by using an objective function, R^2 . R^2 is defined as $R^2=1-\sum [(measured_i-predicted_i)^2/(mean\ measured_i)^2]$, where $measured_i$ are the measured ground water head data, $predicted_i$ are the modeled ground water head data, and mean is the mean of measured ground water head data.

A-3.5.2. Transport Calibration

The Tnbs₂ FEFLOW model relies primarily on the flow calibration to ensure robustness; however, some transport parameters (longitudinal and transverse dispersivity) were also calibrated. The calibrated longitudinal dispersivity that best matched the observed data was 10 ft and the calibrated transverse dispersivity that best matched the observed data was 1 ft, or 10% of the longitudinal dispersivity.

The Tnbs₂ transport calibration was achieved by recreating the present-day TCE plume using a mass flux term applied at the source area. For this calibration, a 0.0025 milligram per liter (mg/L) point source was applied at the primary TCE source area, Building 815. The point source was a “step function” that was applied at a constant rate for 25 years, approximating the period between 1955 to 1980. The contaminant plume was then observed after another 30 years of transient transport and compared with present-day (second quarter 2010) TCE data. To improve the transport calibration, longitudinal and transverse dispersivities were then adjusted and the transport calibration rerun if necessary.

Results of the Tnbs₂ HSU transport calibration found that a source term of 0.0025 mg/L applied for 25 years was able to match the general plume shape and concentration distributions in the upper and middle portions of the Tnbs₂ HSU. The capability of the model to match observed data using a ‘step-function’ point source suggests that the Building 815 Source Area is no longer contributing significant mass to the TCE plume within the Tnbs₂ HSU. It also verifies the validity of the Tnbs₂ HSU conceptual model. Nevertheless, using a single point source, the model was not able to match TCE concentrations near the site boundary. This suggests that another source, probably located in the Building 832 Canyon OU, may have contributed to the TCE plume in this area.

Intermittent pumping at onsite and offsite water supply wells such as Well 6 (now abandoned) and GALLO1 have also impacted the spatial distribution of TCE in the Tnbs₂ HSU. As a result, a closer match between the measured and modeled concentration data is not likely using a steady-state flow model. Offsite water supply well GALLO1 was pumped at a constant rate of 1 gpm during the transport calibration. Well 6 pumping was not included.

A-4. Model Results

To evaluate capture zones, two flow scenarios were considered. Scenario 1 was simulated using the extraction wells, injection wells and flow rates that were typical of wellfield operations during the past five years. The extraction and injection wells and capture zones associated with this scenario are shown on Figure A-4. Scenario 2 (also shown on Figure A-4) was simulated using the “As Designed” extraction wellfield. This wellfield included proposed 815-SRC

extraction well W-815-2803, and 815-DSB extraction wells W-815-2608 and W-815-2621 (both wells are currently monitor wells). Proposed extraction wells are shown in red. Scenario 2 also included increased pumping from the 815-PRX and 817-PRX extraction wells. To represent intermittent pumping at offsite water-supply well GALLO1, the well was pumped at a flow rate of 1 gpm during the steady-state simulations.

As shown on Figure A-4, the Scenario 2 “As Designed” extraction wellfield is expected to expand the areas of hydraulic capture, yet low yields and steep topography continue to limit the locations where new extraction and injection wells may be installed. Based on previous modeling studies, the HEPA OU has a long-term sustainable yield of 15-20 gpm (Ferry et al., 2006). To minimize pulling contaminants toward the Site 300 boundary, pumping at 815-DSB is balanced with upgradient pumping at the Building 815 and 817 source areas.

Distributions of TCE, RDX, and perchlorate within the model domain after 25 years of pumping using the Scenario 2 “As Designed” extraction wellfield are shown in Figure A-5. RDX has a high retardation factor and tends to sorb onto the porous media, making it not only less mobile than the TCE or perchlorate, but also more difficult to remediate. These simulations (Figure A-5) indicate that TCE, RDX and perchlorate plume concentrations greater than drinking water standards will persist after 25 years of cleanup.

A-5. Cleanup Times Estimates

The FEFLOW model was used to make preliminary estimates of the time required to clean up the TCE, RDX, and perchlorate plumes in the Tnbs₂ HSU to a cleanup standard of 5 µg/L, 1 µg/L and 6 µg/L respectively. The predictions were simulated using the Scenario 2 “As Designed” extraction wellfield with constant flow rates specified at each existing and proposed extraction well. The wells used in the Scenario 1 and Scenario 2 simulations are shown on Figure A-4. To represent intermittent pumping, offsite water-supply well Gallo1 was pumped at a constant rate of 1 gpm.

For all three COCs, it was assumed that the HEPA source areas did not continue to contribute mass beyond what was initially present. It was also assumed that extraction wellfields remained unchanged over time; however, in reality, optimization of the extraction wellfields could significantly reduce future cleanup time estimates.

As shown on Figure A-6, the time required to cleanup the Tnbs₂ HSU to the appropriate cleanup standard under non-optimized conditions was approximately 100 years for TCE, 445 years for RDX and 45 years for perchlorate. The dashed portions of the curves shown on Figure A-6 indicates the increasing uncertainty that exists in all model predictions as the estimated time period moves farther from the initial conditions. The retardation factors used for the simulations were 3.1 for TCE, 4.2 for RDX, and 1.0 for perchlorate. To better match the SWRSR modeling studies, the RDX retardation factor was increased to 6.6, resulting in cleanup times estimates of 700 years for cleanup of RDX to 1 µg/L. Based on the modeling studies done in the SWRSR, estimates of cleanup times to 5 µg/L for TCE ranged from 110-120 years and estimates of cleanup times for RDX to 1 µg/L ranged from 800-1000 years. Due to the uncertainty associated with the modeling process, cleanup times for the Tnbs₂ HSU are expected to fall within a range of plus or minus twenty-five years.

A-6. Conclusions

This appendix provides an overview of the FEFLOW model used for the HEPA OU.

The following conclusions were derived from the modeling:

- Figure A-4 shows the capture zones estimated using the Scenario 1 “Five-year Average” and Scenario 2 “As Designed” extraction wellfields. The wells associated with each scenario are listed on this figure. As depicted, potential new extraction wells W-815-2621 and W-815-2608 (shown in red) are expected to increase hydraulic capture near the site boundary. Proposed extraction well W-815-2803 (also shown in red) is expected to increase hydraulic capture near the 815-SRC treatment facility. Figure A-4 also shows the estimated impact of increased extraction flow rates from 817-PRX extraction well W-817-03 and 815-PRX extraction wells W-818-08 and W-818-09.
- Figure A-5 depicts the spatial distributions of TCE, RDX, and Perchlorate after 25 years of pumping using the Scenario 2 “As Designed” extraction wellfield. Simulations of cleanup under non-optimized conditions in the Tnbs₂ HSU using this pumping scenario indicate that TCE, RDX, and perchlorate plume concentrations greater than drinking water standards are expected to persist after 25 years of pumping.
- As shown on Figure A-6, the time required to achieve cleanup of TCE to the 5 µg/L cleanup standard was estimated to be 100 years as compared to the 110-120 years predicted by the SWRSR modeling studies. Perchlorate contamination is contained within the footprint of the TCE plume and is expected to be cleaned up in a shorter duration of time. Optimization of the extraction wellfields may reduce future cleanup time estimates.
- Also shown on Figure A-6, cleanup time estimates for RDX under non-optimized conditions extend into the hundreds of years due to the highly sorptive nature of this contaminant. Sorption tends to impede cleanup, leading to longer cleanup times. In implementation; however, DOE/LLNL will continuously monitor the remediation of the RDX plume to better target contaminants and to minimize cleanup times.
- Results of the Tnbs₂ transport calibration found that a source term of 0.0025 mg/L applied near the Building 815 source area for 25 years was able to match the general plume shape and concentration distributions. A closer match is not likely using a steady-state approximation of intermittent pumping at water supply Well 6 (now abandoned) and offsite water supply well Gallo1. The capability of the model to match the spatial distribution of observed TCE concentration data using a ‘step-function’ point source suggests that the Building 815 Source Area is no longer contributing significant mass to the TCE plume within the Tnbs₂ HSU. Other sources, including sources located in the Building 832 Canyon OU, may also be contributing to the TCE plume within the Tnbs₂ HSU.
- All hydraulic capture zones shown in this appendix are conservative estimates based on model results. Observed capture zones may be significantly larger due to the presence of interconnected fracture networks.

A-7. References

- Diersch, H. G. (1998), Reference Manual, “FEFLOW- Interactive, Graphics-based Finite-Element Simulation System for Modeling Ground water Flow, Contaminant Mass and Head Transport Processes,” WASY Institute for Water Resources Planning and Systems Research Ltd., Berlin, Germany.
- Ferry, L., M. Dresen, Z. Demir, V. Dibley, V. Madrid, M. Taffet, S. Gregory, J. Valett, M. Denton (2006), *Final Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-220391).
- Madrid, V. M. and B. J. Jakub (1998), *Engineering Evaluation/Cost Analysis for the Building 815 Operable Unit Removal Action Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-126639).
- Pelmulder, S. D., and R. M. Maxwell (1997), “Site 300 Building 815 Ground water Modeling Report,” The Center for Nuclear and Toxic Waste Management, University of California-Berkeley, Berkeley, CA (Draft).
- U.S. DOE (2008), *Final Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-236665).

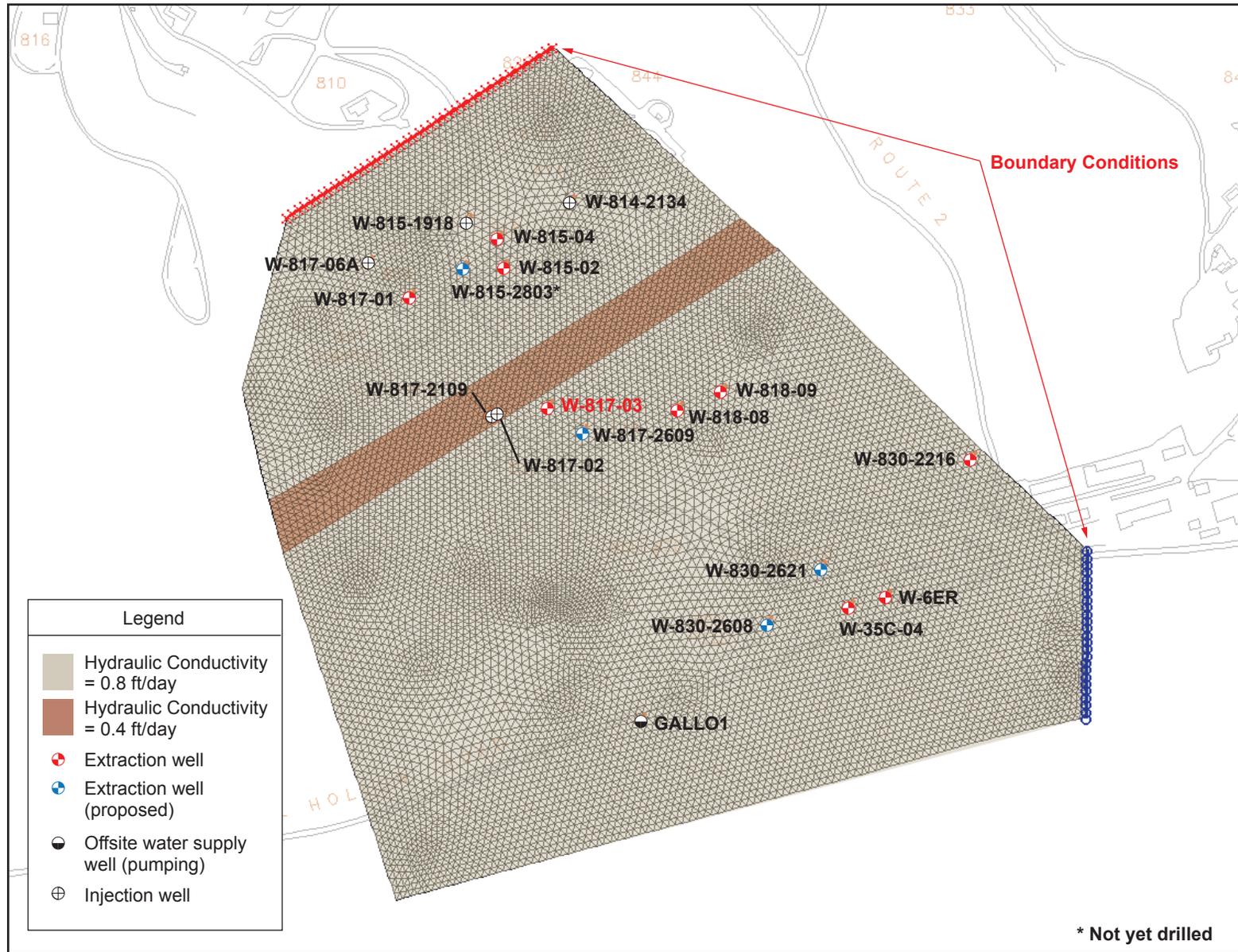
Appendix A

Figures

Appendix A

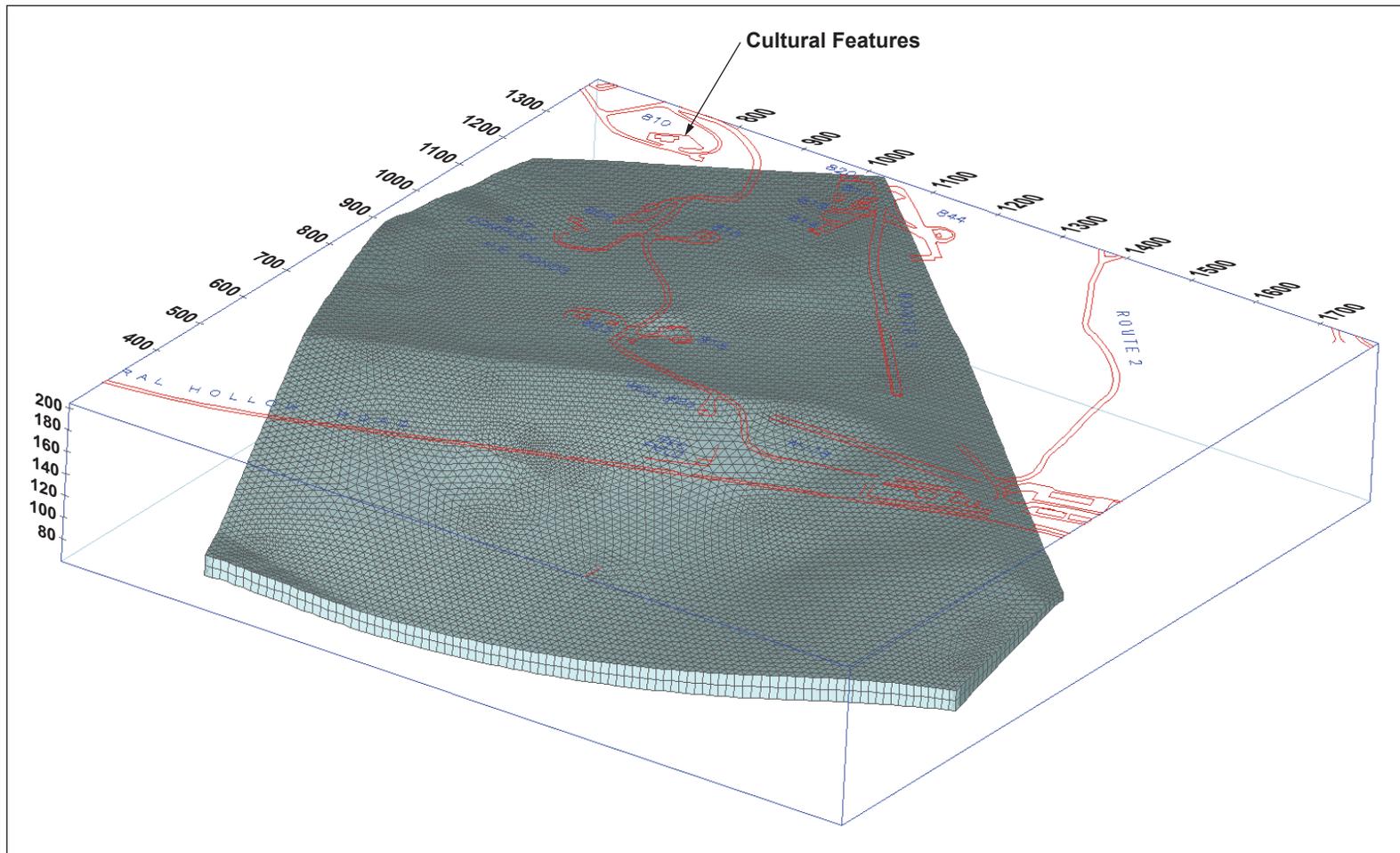
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- Figure A-4. Capture zone analysis results for the a) Scenario 1 “Five-Year Average” and b) Scenario 2 “As Designed” remedial extraction wellfields as simulated by the Tnbs₂ hydrostratigraphic unit FEFLOW model.
- Figure A-5. TCE, RDX and Perchlorate isoconcentration contours simulated using the Tnbs₂ FEFLOW model after 25 years of pumping using the Scenario 2 “As Designed” extraction wellfield.
- Figure A-6. Preliminary maximum TCE, Perchlorate, and RDX concentrations predicted over time in the Tnbs₂ HSU with cleanup standards.



ERD-S3R-11-0180

Figure A-1. Map showing the Tnbs₂ FEFLOW model domain, grid, boundary conditions, hydraulic conductivity field, cultural features and location of existing and proposed extraction wells included in the Scenario 2 “As Designed” simulation.



ERD-S3R-11-0181

Figure A-2. A three-dimensional visualization of the finite-element grid used for the Tnbs₂ FEFLOW model.

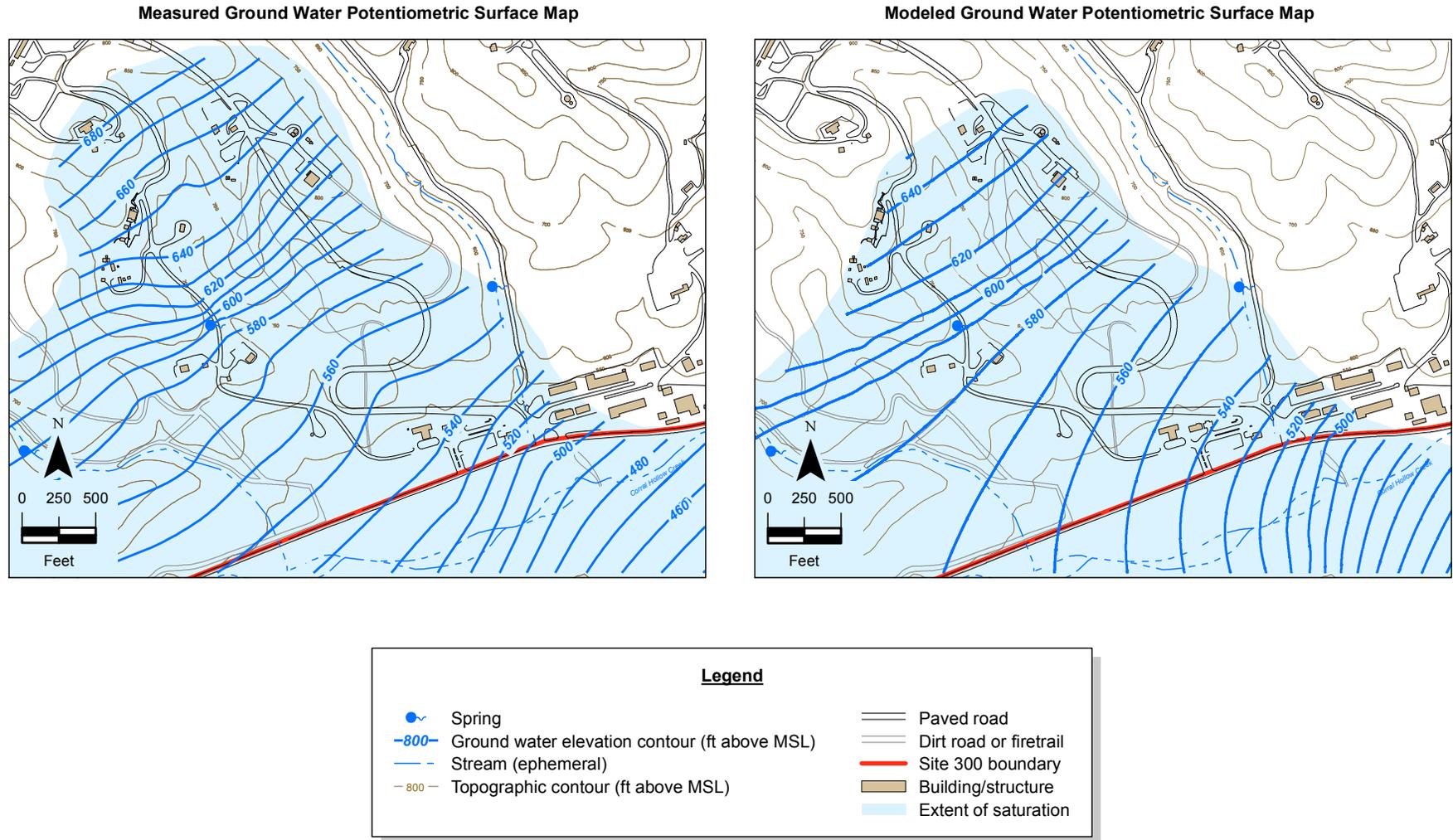


Figure A-3. Measured and modeled ground water potentiometric surface maps used for and resulting from the Tnbs₂ FEFLOW model calibration.

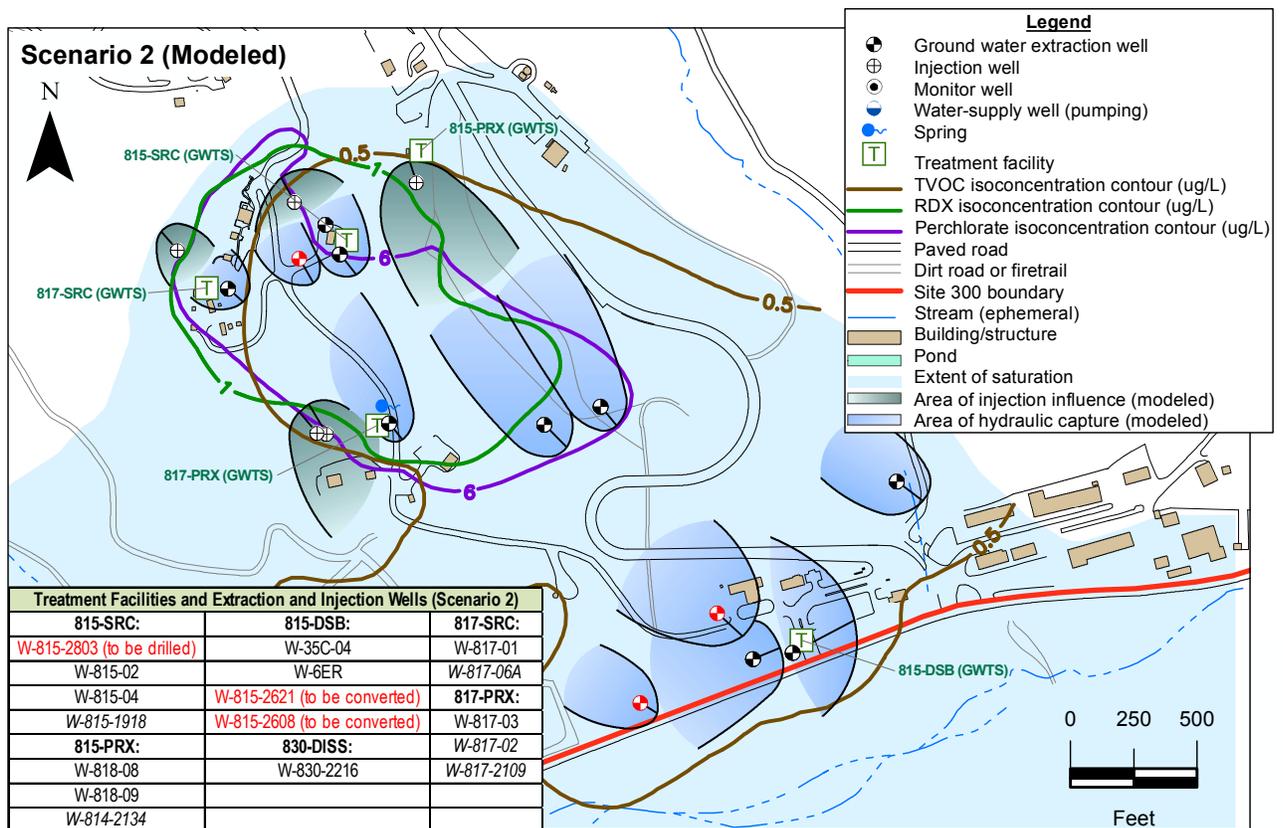
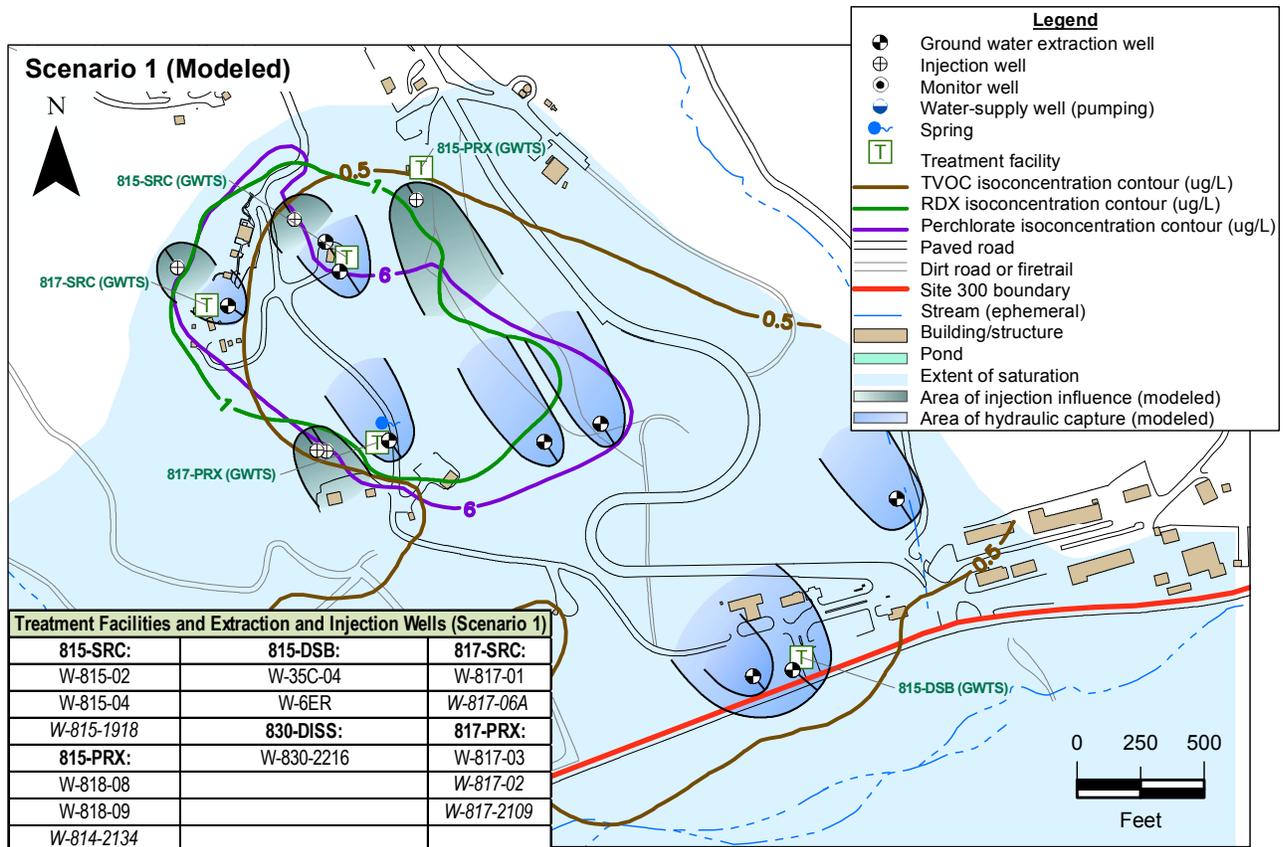


Figure A-4. Capture zone analysis results for the a) Scenario 1 "Five-Year Average" and b) Scenario 2 "As Designed" remedial extraction well fields as simulated by the Tnbs₂ hydrostratigraphic unit FEFLOW model.

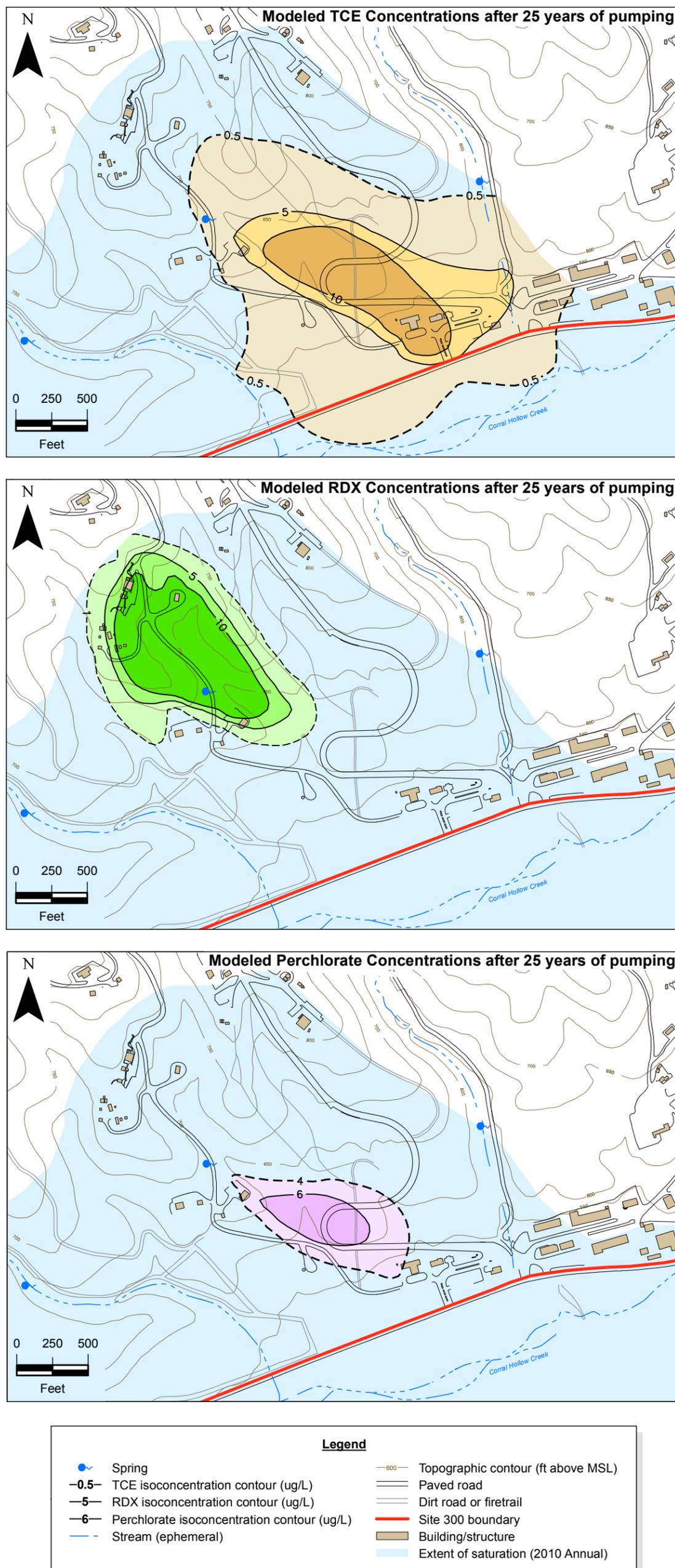
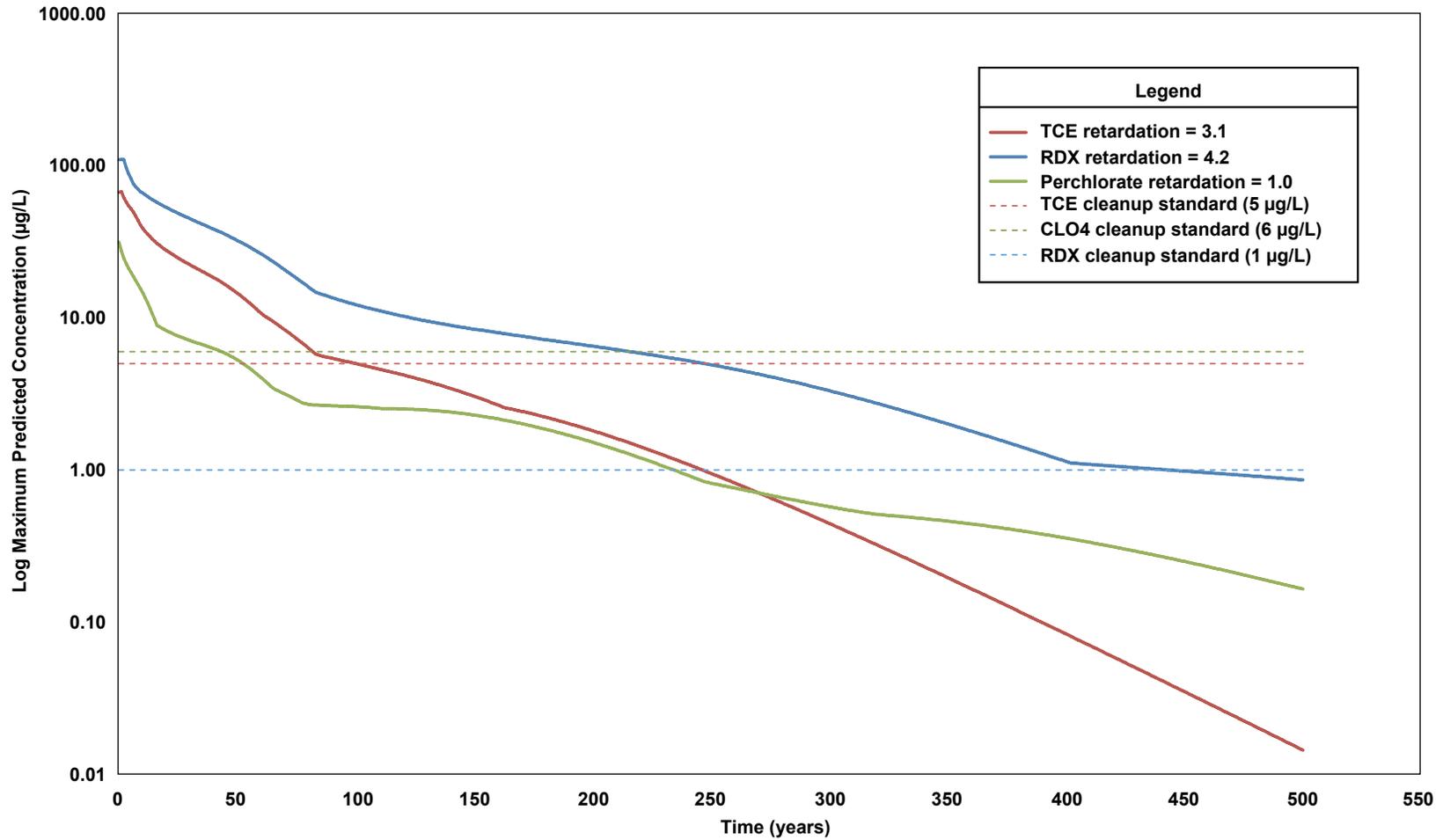


Figure A-5. TCE, RDX and Perchlorate isoconcentration contours simulated using the Tnbs₂ FEFLOW model after 25 years of pumping using the Scenario 2 “As Designed” extraction wellfield.



ERD_S3R_11_0184

Figure A-6. Preliminary maximum TCE, Perchlorate, and RDX concentrations predicted over time in the Tnbs₂ HSU with cleanup standards.

Attachment A

High Explosives Process Area

Five-Year Review Inspection Checklist

**High Explosives Process Area Operable Unit
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300**

I. SITE INFORMATION

Site Name: High Explosives Process Area (HEPA) Operable Unit (OU), LLNL Site 300

Date of inspection: March 31, 2011

Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California

EPA Region: 9

EPA ID: CA 2890090002

Agency Leading the Five-Year Review: U.S. Department of Energy (DOE) –
Livermore Site Office (LSO)

Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:

- Monitoring to evaluate the effectiveness of the remedial action in achieving cleanup standards.
- Risk and hazard management (including institutional and administrative controls) to prevent onsite workers exposure to volatile organic compounds (VOCs) volatilizing from subsurface soil and impacts to animals until risk and hazard is mitigated through active remediation.
- Extracting and treating VOCs, HE compounds, and perchlorate in ground water to mitigate unacceptable VOC inhalation risk for onsite workers, prevent further impacts to ground water and offsite plume migration, and reduce contaminant concentrations in ground water to cleanup standards.
- Monitoring Natural Attenuation (MNA) of nitrate in ground water.

Site Map: See HEPA OU Five-Year Review Figure 1.

II. INTERVIEWS

1. O&M Site Manager

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE): Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

Remarks: As there is a full-time presence of the DOE-LSO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and the HEPA OU treatment facility operator at the site, the oversight, inspections, evaluations, and discussions of the HEPA OU remedy are ongoing. Remedy performance, facility operations, and any related issues are managed in real-time in collaboration with the Field Operations Manager, the facility operator, and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single “interview” of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection checklist is a compilation of this and other DOE-LSO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the HEPA OU remedy and treatment facility. In addition, DOE/LLNS presents and discusses any treatment facility operations and maintenance (O&M) or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):

- Steve Orloff, Site 300 ER Field Operations Manager.
- Larry Griffith, Operator - HEPA ground water extraction and treatment systems.
- David Graves, Operator - HEPA ground water extraction and treatment systems.
- Todd Tramell, Operator - HEPA ground water extraction and treatment systems.

Remarks: As there is a full-time presence of the DOE-LSO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and HEPA OU treatment facility operators at the site, the oversight, inspections, evaluations, and discussions of the HEPA OU remedy are ongoing. Facility operations and any related issues are managed in real-time by the entities listed above in collaboration with full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling & Analysis Teams. As such, there was no single “interview” of O&M staff or interview results that can be referenced. The information contained within this

inspection checksheet is a compilation of this and other DOE-LSO RPM routine inspections, evaluations, and discussions regarding the HEPA OU remedy and treatment facility.

3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

1. O&M Documents

O&M manual:	Readily available and up-to-date
As-built drawings:	Readily available and up-to-date
Maintenance logs:	Readily available and up-to-date

Remarks: As-built drawings for the HEPA OU treatment facilities are maintained in the LLNL Environmental Restoration Department files. The HEPA OU treatment facilities consist of the Building 815-Source (815-SRC), Building 815-Proximal (815-PRX), Building 815-Distal Site Boundary (815-DSB), Building 817-Source (817-SRC), Building 817-Proximal (817-PRX), and Building 829-Source (829-SRC). The HEPA OU treatment facilities maintenance activities are recorded in a facility-specific logbook maintained by the facility operator. In addition, facility maintenance activities are discussed in monthly Project Updates submitted to the regulatory RPMs, at regular RPM meetings, and in the semi-annual and annual Site-Wide Compliance Monitoring Reports.

2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan:	Readily available and up-to-date
Contingency plan/emergency response plan:	Readily available and up-to-date

Remarks: Site-specific health and safety information for Environmental Restoration activities is contained in the “Site Safety Plan for LLNL CERCLA Investigations at Site 300.” Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

Other permits: None.

5. Gas Generation Records

Gas Generation Records: Not applicable

6. Settlement Monument Records

Settlement Monument Records: Not applicable

7. Ground water Monitoring Records

Ground water Monitoring Records: Readily available and up-to-date

Remarks: Ground water monitoring records for the HEPA OU are maintained in the LLNL ER Department's Taurus Environmental Information Management System (TEIMS) database. The ground water compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the California Department of Toxic Substances Control (DTSC), and are available on-line at www-erd.llnl.gov/library/index.html

8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

9. Discharge Compliance Records

Air: Not applicable

Water: Readily available and up-to-date

Remarks:

Air: No vapor treatment is performed in the HEPA OU.

Water (effluent): The HEPA OU ground water extraction and treatment systems effluent discharge compliance records are maintained in the LLNL ER Department's TEIMS data base, and are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and DTSC, and are available on-line at www-erd.llnl.gov/library/index.html

10. Daily Access/Security Logs

Daily Access/Security Logs: Readily available and up-to-date

Remarks: The HEPA OU treatment facilities maintenance activities are recorded in a facility-specific logbook maintained by the facility operators. Site 300 is a restricted access facility and badging and clearance that must be presented to a security force guard is required to gain entry to the site.

IV. O&M COSTS

1. O&M Organization

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

2. O&M Cost Records

O&M Cost Records: Readily available and up-to-date
Funding mechanism in place

Remarks: The actual annual costs for the HEPA OU during the review period (2007-2011) are presented in Table 1 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LSO RPM on HEPA OU restoration planned and actual costs with explanations/justifications of any cost variances.

3. Unanticipated or Unusually High O&M Costs During the Review Period

Describe costs and reasons: No unanticipated or unusually high O&M costs were incurred during the review period. As described in Table 1 of the HEPA Five-Year Review, costs for the HEPA OU were consistently under budget for the review period due to lower than expected operations, maintenance, and optimization costs.

V. ACCESS AND INSTITUTIONAL CONTROLS

Applicable

A. Fencing

1. Fencing Damaged

Fencing damaged location: Fencing in good condition
Gate secured: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access.

B. Other Access Restrictions

2. Signs and Other Security Measures

Signs and Other Security Measures In place Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

C. Institutional Controls (ICs)

1. Implementation and Enforcement

Site conditions imply ICs not properly implemented: No
Site conditions imply ICs not being fully enforced: No

Type of monitoring (e.g., self-reporting, drive by): Physical inspection
Frequency:

Physical ICs are inspected annually.
ICs are reviewed annually for adequacy and protectiveness.

Responsible party/agency: U.S DOE
Contact Name: Claire Holtzapple
Title: DOE-LSO Site 300 Environmental Restoration RPM
Phone No.: 925/422-0670

IC Inspection Date: November 4, 2010

Reporting is up-to-date:	Yes
Reports are verified by the lead agency:	Yes
Specific requirements in deed or decision document have been met:	Yes
Violations have been reported:	Not Applicable
Other problems or suggestions:	None

Remarks: Refer to Section 4.4. (Institutional Controls) of the HEPA OU Five-Year Review for further details on institutional controls in the HEPA OU.

2. Adequacy

ICs are adequate: Yes

Remarks: Refer to Section 4.4. (Institutional Controls) of the HEPA Five-Year Review for further details on institutional controls in the HEPA OU.

D. General

1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

2. Land Use Changes Onsite

Land Use Changes Onsite: None

Remarks: There have been no changes in land, building, or ground water use in the HEPA OU since the Site-Wide Record of Decision and none are anticipated. Facilities in the HEPA have been in use since the late 1950s for the chemical formulation, mechanical pressing, and machining of HE compounds into shaped detonation devices. At Site 300, ground water is used for a variety of needs including cooling towers, HE processing, and fire suppression. Bottled water is the primary source of onsite drinking water, however potable ground water from onsite water-supply Well 20, located in the HEPA OU, is available as necessary for potable supply. The use of Well 18, also located in the southeast part of the HEPA OU, as a water-supply well was discontinued due to sporadic detections of TCE in samples from this well. Although Well 18 is inactive, it is considered a backup well to supply

water for emergency fire suppression. Site 300 is currently scheduled to transition to Hetch Hetchy water as its primary onsite water supply in 2013. Refer to Section 3.2. (Land and Resource Use) of the HEPA OU Five-Year Review for further details on institutional controls in the HEPA OU.

3. Land Use Changes Offsite

Land Use Changes Offsite: Not applicable

Remarks: Current offsite land use near the OU includes agriculture, private residences, and an ecological preserve. The nearest major population center (Tracy, California) is 8.5 miles to the northeast. While there is offsite development proposed adjacent to and north of Site 300 (the Tracy Hills Development), this development does not border the HEPA OU. There is no known planned modification or proposed development of the offsite land adjacent to the OU. There are private offsite water-supply wells in use near the OU. Refer to Section 3.2. (Land and Resource Use) of the HEPA Five-Year Review for further details on institutional controls in the HEPA OU.

VI. GENERAL SITE CONDITIONS

A. Roads

1. Roads Damaged

Roads damaged location: Roads adequate

Remarks: The HEPA OU treatment facilities and wells are accessed by roads maintained by the LLNL Site 300 management.

B. Other Site Conditions

Remarks: The HEPA OU treatment facilities and wells are maintained in good condition by the LLNL Site 300 management.

VII. LANDFILL COVERS

Not applicable

VIII. VERTICAL BARRIER WALLS Not applicable

IX. GROUND WATER/SURFACE WATER REMEDIES Applicable

A. Groundwater Extraction Wells, Pumps, and Pipelines Applicable

1. Pumps, Wellhead Plumbing, and Electrical

Good condition: Yes
All required wells properly operating: Yes

Remarks: The ground water extraction wells are inspected weekly and are in good condition and operating properly.

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances

Good condition: Yes

Remarks: All extraction system pipelines and valves are inspected weekly and are in good condition.

3. Spare Parts and Equipment

Readily available: Yes
Good condition: Yes

Remarks: Spare parts for routine equipment maintenance are readily available and in good condition.

B. Surface Water Collection Structures, Pumps, and Pipelines Not applicable

C. Treatment System Applicable

1. Treatment Train (check components that apply)

Metals removal:	Not applicable
Air Stripping:	Not applicable
Oil/Water separation:	Not applicable
Bioremediation:	Not applicable
Carbon adsorbers:	Yes
Filters: Cuno particulate filters:	Yes
Additive (e.g., chelation agent, flocculent):	Not applicable
Good condition:	Yes
Sampling ports properly marked and functional:	Yes
Sampling/maintenance log displayed and up-to-date:	Yes
Equipment properly identified:	Yes
Quantity of ground water treated annually:	3,126,000 gallons
Quantity of surface water treated annually:	Not applicable
Quantity of soil vapor treated annually:	Not applicable

* Quantities based on 2010 annual totals.

Remarks: Refer to Section 4.3 (System Operations/Operations and Maintenance of the HEPA OU Five-Year Review for further details about the HEPA OU ground water extraction and treatment systems operations and maintenance. Photographs of the ground water extraction and treatment systems are included in Attachment A.

2. Electrical Enclosures and Panels (properly rated and functional)

Good condition:	Yes
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Remarks: The electrical control panel and enclosure are in good condition, properly rated, and functional.

3. Tanks, Vaults, Storage Vessels

Good condition:	Not applicable
Proper secondary containment	Not applicable

4. Discharge Structure and Appurtenances

Good condition:

Yes

Remarks: The effluent from HEPA ground water extraction and treatment systems is discharged to infiltration trenches or injection well(s). See table below.

Treatment System	Discharge Method
815-SRC	Reinjection well W-815-1918
815-PRX	Reinjection well W-815-2134
815-DSB	Infiltration trench
817-SRC	Reinjection well W-817-06A
817-PRX	Reinjection wells W-817-2109 and W-817-02
829-SRC	Reinjection well W-829-08

5. Treatment Buildings

Not applicable

6. Monitoring Wells

Properly secured/locked:

Yes

Functioning:

Yes

Routinely sampled:

Yes

Good condition:

Yes

All required wells located:

Yes

Needs maintenance:

None

Remarks: The current HEPA OU wellfield consists of 10 ground water extraction wells, six ground water injection wells, three water supply wells, and 79 ground water monitor wells. During 2010, ground water monitoring was conducted in accordance with the CMP monitoring requirements with the following exceptions; twenty-nine required analyses were not performed because there was insufficient water in the wells to collect the samples and twenty-two required analyses were not performed due to an inoperable pump.

D. Monitoring Data

1. Monitoring Data

Is routinely submitted on time:	Yes
Is of acceptable quality:	Yes

2. Monitoring data suggests:

Ground water plume is effectively contained:	Yes
Contaminant concentrations are declining:	Yes

Remarks: Refer to Section 7.5.2 (Ground Water Remediation Progress) of the HEPA OU Five-Year Review for further details on the progress of the remedial action at the HEPA OU.

E. Monitored Natural Attenuation

1. Monitoring Wells (natural attenuation remedy)

Properly secured/locked:	Yes
Functioning:	Yes
Routinely sampled:	Yes
Good condition:	Yes
All required wells located:	Yes
Needs maintenance:	None

Remarks: MNA is the remedy for nitrate in the majority of the OU. Samples are collected annually and reported in the Compliance Monitoring Reports.

X. OTHER REMEDIES	Not Applicable
--------------------------	----------------

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the HEPA OU is intended to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, reduce contaminant concentrations in ground water to cleanup standards, and mitigate VOC inhalation risk to onsite workers. Refer to Section 4.1 (Remedy Section) for further details on the remedial action objectives of the HEPA OU remedy.

The remedy at the HEPA OU is effective, functioning as designed, and is protective of human health and the environment for the site's industrial land use. Refer to Section 8 (Technical Assessment) and Section 11 (Protectiveness Statement) of the HEPA OU Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.

No deficiencies in the remedy for the HEPA OU were identified during this evaluation. Refer to Section 9 (Deficiencies) and Section 10 (Recommendations and Follow-up Actions) of the HEPA OU Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the HEPA OU ground water extraction and treatment facilities.

C. Early Indicators of Potential Remedy Problems

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the remedy at the HEPA OU may be compromised in the future. DOE's long-term plans include periodic assessments and upgrades to the HEPA OU ground water extraction and treatment systems to ensure the effectiveness and protectiveness of the remedy.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

DOE identified the following opportunities to improve remedy performance:

-
1. Drill and install one new extraction well (W-815-2803) to increase hydraulic capture and mass removal in the Building 815 source area and to prevent migration of volatile organic compounds (VOCs), high explosive (HE) compounds, and perchlorate in the Tnbs₂ hydrostratigraphic unit (HSU). This extraction well will be connected to the Building 815-Source (815-SRC) treatment facility where extracted ground water will be treated. The well is scheduled to be drilled in 2012 and will be connected to 815-SRC in 2014.
 2. Convert Tnbs₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent offsite migration of VOCs, and connect it to the 815-Distal Site Boundary (DSB) ground water treatment system for VOC removal. The well is scheduled to be connected to the 815-DSB facility in 2012. Tnbs₂ HSU monitor well W-815-2621 will be evaluated to determine its suitability as an extraction well.
 3. Drill and install one new monitor well (W-817-2XM1) to monitor HE compounds, perchlorate, and nitrate concentration trends near the 817-SRC treatment facility in the Tnbs₂ HSU. The proposed monitor well will assess the effectiveness of the 817-SRC recirculation cell between extraction well W-817-01 and effluent injection well W-817-06A. This well is scheduled to be drilled in 2014.
 4. Drill and install one new monitor well (W-815-2XM1) to monitor VOCs, HE compounds, perchlorate, and nitrate concentration trends near the Building 815 source area in the Tpsg-Tps HSU. This well is scheduled to be drilled in 2014.
 5. Over the next five-years:
 - Evaluate Tnbs₂ HSU well W-817-2609 in the 817-Proximal area by monitoring contaminant concentrations trends in this well and nearby well W-817-03 to determine whether to convert well W-817-2609 to an extraction well.
 - Identify potential locations for two additional effluent injection wells to allow 817-PRX extraction rates to be increased in the Tnbs₂ HSU.
 6. Operation of and hydraulic capture zones for existing and new extraction wells in the HEPA OU will be evaluated over the next five years and documented in the Annual Compliance Monitoring Reports. Based on this data, DOE/LLNS will pursue opportunities to optimize wellfield operations to maximize contaminant removal as they are identified.

Refer to Section 9 (Recommendations and Follow-up Actions) in the HEPA OU Five-Year Review for further details on DOE recommendations for remedy optimization.

Attachment A

High Explosives Process Area Operable Unit Five-Year Review Inspection Checklist

Ground water extraction and treatment system photographs



Building 815-Source ground water extraction and treatment system began operation in 2000. Trichloroethene and Research Department Explosive are removed from extracted ground water by aqueous-phase granular activated carbon. Ion-exchange columns remove perchlorate. Nitrate-bearing effluent is discharged into an injection well for *in situ* denitrification.



Building 815-Proximal ground water extraction and treatment system began operation in 2002. Trichloroethene is removed from extracted ground water by aqueous-phase granular activated carbon. Ion-exchange columns remove perchlorate. Nitrate-bearing effluent is discharged into an injection well for *in situ* denitrification.



Building 815-Distal South Boundary ground water extraction and treatment system began operation in 1999. Trichloroethene is removed from extracted ground water by aqueous-phase granular activated carbon. Treated ground water is discharged to the subsurface via an infiltration trench.



Building 817-Source ground water extraction and treatment system began operation in 2003. Ground water is extracted utilizing solar power. Research Department Explosive is removed from extracted ground water by aqueous-phase granular activated carbon. Ion-exchange columns remove perchlorate. Nitrate-bearing effluent is discharged into an injection well for *in situ* denitrification.



Building 817-Proximal ground water extraction and treatment system began operation in 2005. Trichloroethene and Research Department Explosive are removed from extracted ground water by aqueous-phase granular activated carbon. Ion-exchange columns remove perchlorate. Nitrate-bearing effluent is discharged into an injection well for *in situ* denitrification.



Building 829-Source ground water extraction and treatment system began operation in 2005. Ground water is extracted utilizing solar power. Volatile organic compounds are removed from extracted ground water by aqueous-phase granular activated carbon. Ion-exchange columns remove perchlorate and nitrate. Effluent is discharged into an injection well.

Attachment B
Responses to Regulatory Comments

Comment Responses for the Draft Five-Year Review Report for the High Explosives Process Area Operable Unit (OU) at Lawrence Livermore National Laboratory (LLNL) Site 300

U.S. Environmental Protection Agency (EPA) Comments on the Draft Five-Year Review for the High Explosives Process Area at LLNL Site 300

GENERAL COMMENTS

1. The Explosives Process Area (HEPA) volatile organic compound (VOC) groundwater plume flows beneath the medical clinic building and the former site cafeteria, yet inhalation risk to workers in these buildings is not considered nor discussed in the Report. This should be considered as part of the protectiveness evaluation. Figures 5 and 14 indicate that the total VOC concentration beneath these buildings is higher than beneath Building 815, but the evaluation of inhalation risk and excess cancer risk focuses only on Building 815 and Spring 5. The text should discuss the number of workers in these buildings and evaluate the excess cancer risk specifically to workers in these buildings. Revise the Report to consider the excess cancer risk to workers in the medical clinic building and the former site cafeteria and include this evaluation in the protectiveness evaluation. Given that the plume extended in this direction in 2005 (Figure 16) it is not clear to EPA why this was not evaluated in the 2007 5YR.

Response: Due to the presence of a low permeability confining layer, the Tnsc₂ siltstone/claystone, that overlies the Tnbs₂ hydrostratigraphic unit (HSU), the Tnbs₂ HSU is confined throughout the southern portion of the HEPA. Therefore, a direct pathway is not present that would allow VOCs to be transported in the vapor phase from Tnbs₂ HSU ground water through the vadose zone to the ground surface or into buildings in these areas.

2. The institutional controls (ICs) in Table 2 do not include the medical clinic building and the former site cafeteria, so it is unclear how workers in these buildings will be protected. It appears that an Explanation of Significant Differences (ESD) may be necessary to incorporate these buildings into the Site-Wide Record of Decision (ROD). Include a recommendation for an ESD to address the medical clinic building and the former site cafeteria.

Response: Please refer to the response to EPA General Comment #1.

3. Offsite private well GALL02 is shown in a figure transmitted to EPA on July 16, 2012. This well is very close to the downgradient end of a small VOC plume not identified in the draft document.

Responses to Regulatory Comments on the Draft Five-Year Review for the High Explosives Process Area OU at LLNL Site 300

The document should be revised to include this new plume and assess remedy protectiveness in this area. Capture zones identified in the draft 5YR do not appear to address this plume. In addition, an approach (e.g. Institutional Controls) is needed to ensure that well Gallo2 does not become a source of contaminant exposure in the future.

Response: Well GALLO2 is located on the Gallo Ranch property south of Site 300. This well is thought to have been drilled in the 1940s. There is no pump in this well, and it has not been used for many years. No VOCs have ever been detected in this well and because this well is not being pumped, it is not expected to have any future impact on any nearby VOC plumes. The offsite plume located near GALLO2 and shown on the figure transmitted to EPA on July 16 emanates from Central General Services Area (GSA) dry well pad. Capture zones for this plume are discussed in the recent GSA Five-Year Review report.

SPECIFIC COMMENTS

1. **Cover:** The title and title page of the Report do not indicate the sequence number of this Five Year Review Report, i.e., the Second Five-Year Review, as indicated on page E-9 of Appendix E of the Comprehensive Five-Year Review Guidance (the Guidance; EPA, 2001). Revise the title page to specify the review number for this Report.

Response: The title page was revised to indicate that this is the second five-year review for the HEPA OU.

2. Five Year Review Summary Form:

- a. (page 6 of 113, pdf) – the document should use the new format for the 5YR Summary Form. The revised form is explicit about follow-up action due dates and responsible parties for implementation. The file can be downloaded here: http://www.epa.gov/superfund/cleanup/postconstruction/5yr_reviewform.htm

The triggering action date is technically that of EPA concurrence on the previous 5YR [11/30/2012], and the actual due date is 11/30/2012. EPA appreciates the Lab expediting the deliverable.

Response: The Summary Form has been modified utilizing the new format, including follow-up action due dates and the responsible party for implementation.

The due date in the Summary Form has been changed to November 12, 2012 to reflect the revised milestone date in the regulatory-approved 2011 Site 300 Chronological Schedule of Deliverables, with two weeks added as a result of the

Responses to Regulatory Comments on the Draft Five-Year Review for the High Explosives Process Area OU at LLNL Site 300

two week extension in the regulatory review period for the Draft Five-Year Review.

Due to the potential for significant differences between the final document milestone date and the date of EPA concurrence, it is necessary for the U.S. Department of Energy (DOE) to continue to use the milestone date of the final five-year reviews as the trigger date for subsequent five-year reviews. This is necessary because DOE cannot predict when EPA concurrence will occur for any given Five-Year Review. This makes it extremely difficult for DOE to set or meet milestone dates, and plan and manage resources and budgets/funding.

- b. (page 7 of 113, pdf) Deficiencies section – The narrative needs to be revised to reflect the absence of IC's for the off-site plume and the potential VI (vapor intrusion) issue for on-site buildings over plume. Revise copy to include recommendations to address deficiencies noted in a revised "Deficiencies" section. Additionally, the language in item 2, "Convert...to an extraction well...to prevent offsite migration of VOC's..." incorrectly suggests that the plume is not yet off-site.

Response: The Five-Year Review Summary Form was modified to utilize the new EPA format. The absence of ICs to prevent the installation of wells within the offsite VOC plume with concentrations above cleanup standards and to prevent the consumption of contaminated water in offsite well GALLO1 was identified as an issue and a recommendation to address this issue was added to the new Summary Form, Section 4.4 (Institutional Controls), Section 7.3 (Other Information), Section 8 (Issues), Section 9 (Recommendations and Follow-Up Actions), and Section 10 (Protectiveness Statement).

As discussed in the response to EPA's General Comment #1, the Tnbs₂ HSU is confined throughout the southern portion of the HEPA due to the presence of a low permeability confining layer, the Tnsc₂ siltstone/claystone, that overlies the Tnbs₂ HSU. Therefore, a direct pathway is not present that would allow VOCs to be transported in the vapor phase from Tnbs₂ HSU ground water through the vadose zone to the ground surface or into buildings in these areas.

The text in Recommendation (item) #2 in the Summary Form and Section 9 (Recommendations and Follow-Up Actions) has been modified to state: "Convert Tnbs₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent further offsite migration of VOCs....."

- c. (page 7 of 113, pdf) Recommendations and Follow-up Actions section – the form indicates there are no deficiencies yet lists six substantial recommendations that the report indicates "do not affect the protectiveness of the remedy." Only those recommendations that are required to ensure remedy protectiveness should be listed in the 5YR Summary Form. 5YR recommendations are tracked in EPA's

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CERCLIS database by due date and responsible party. If the recommendations identified here are not required for protectiveness but are routine plans or modifications to improve or optimize the remedy, then they should be identified in the document text as remedy optimization plans that were identified during the 5YR process and omitted from the 5YR Summary Form. Revise copy to include recommendations to address deficiencies noted in a revised “Deficiencies” section. Also, the language in item 2, “Convert...to an extraction well...to prevent offsite migration of VOC’s....” incorrectly suggests that the plume is not yet off-site.

Response: DOE is the lead agency for the LLNL Site 300 cleanup and therefore, the Five-Year Review is a DOE document. As such, the Five-Year Review Summary Form provides a useful tool to identify recommended additional scope of work to optimize cleanup in the OU for DOE management and to support funding requests. For this reason, the recommendations were not removed from the Summary Form. It is stated in the Summary Form that these recommendations do not affect the protectiveness of the remedy, providing EPA with the necessary justification not to include and track them in the EPA database.

As discussed in the response to EPA’s General Comment #2b, the absence of ICs to prevent the installation of wells within the offsite VOC plume with concentrations above cleanup standards and to prevent the consumption of contaminated water in offsite well GALLO1 was identified as an issue and a recommendation to address this issue was added to the new Summary Form, Section 4.4 (Institutional Controls), Section 7.3 (Other Information), Section 8 (Issues), Section 9 (Recommendations and Follow-Up Actions), and Section 10 (Protectiveness Statement).

As discussed in the response to EPA’s General Comment #2b, the text in Recommendation (item) #2 in the Summary Form and Section 9 (Recommendations and Follow-Up Actions) has been modified to state: “Convert Tnbs₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent further offsite migration of VOCs.....”

d. (page 7 of 113, pdf) Protectiveness Statement section – Revise copy to reflect facts about the off-site plume, on-going use of off-site water supply wells and occasional low-level contaminant detections, yet no IC’s in place; also vapor intrusion (VI) issue. The description about the IC is odd; usually an IC for an active facility prohibits transfer without appropriate deed restriction and SLUC in place, not a total prohibition. Please confirm that the provided description of the ROD is accurate.

Response: As discussed in the responses to EPA’s General Comments #2b and 2c, the Protectiveness Statements in the Summary Form and Section 10 were revised to discuss the absence of ICs to prevent the installation of wells within

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the offsite VOC plume with concentrations above cleanup standards and to prevent the consumption of contaminated water in offsite well GALLO1 and the recommendations to address this issue.

Please refer to the response to EPA's General Comment #1 regarding the vapor intrusion issue.

The FFA allows DOE to transfer the land with a land use covenant. The text in the Protectiveness Statements in the Summary Form and Section 10 have been revised to state: "Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use without a land use covenant in accordance with the FFA."

- 3. Section 1.0, Introduction, page 1:** The second paragraph states that the 'purpose of a Five-Year Review is...to determine whether the remedy will continue to be protective of human health and the environment" but the Five-Year Review must also evaluate whether the remedy is currently protective of human health and the environment. Revise the purpose statement to state that the Five-Year Review must evaluate whether the remedy is currently protective of human health and the environment. Revise the statement at the beginning of Paragraph 2 regarding the purpose of a FYR to include current protectiveness.

***Response:* The second paragraph of the Section 1 (Introduction) was revised as requested.**

- 4. Section 2, Site Chronology, page 11:** Revise 2008 entry which currently states that the "remedy for the HEPA OU did not change between the 2002 and 2008 Site-Wide ROD with the exception [of]...ground water cleanup standards...." This statement is inconsistent with other statements in the FYR in two respects: 1) the 2001 entry on page 10 states that the "Interim Site-Wide ROD" was signed in 2001, not 2002; 2) the Protectiveness Statement in the FYR Summary Form states that the transfer prohibition IC was included in the Site-Wide Record of Decision" (not the "Interim Site-Wide ROD").

***Response:* Section 2 (Site Chronology) was revised to reflect that the Interim ROD was signed in 2001. The 2001 ROD included Risk and Hazard Management (in Section 2.9.1.2 of the ROD) that presented the administrative and engineering controls to be implemented to prevent exposure to contamination. This includes the FFA provision against transfer of lands with contamination without a land use covenant. The 2008 ROD Institutional/Land Use Control language was changed based on newer EPA guidance available at the time.**

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5. **Section 3, Background, page 12:** The 12 confirmed chemical release sites discussed in this section should be depicted on a figure. Please include a figure that depicts the 12 confirmed chemical release sites in the next version of the Report.

Response: There are thirteen confirmed chemical release sites in the HEPA OU include the ten unlined disposal lagoons, the former Building 815 drum rack/hard stand, the former Building 810 dry well, and the former 829 Open Burn Pit. The text in Section 3.1.1 has been changed to reflect this information and these release sites are now all shown on Figure 3.

6. **Section 3.1.1, Site Description, page 12:** Last sentence of the first paragraph on page 12 should be revised because, as currently drafted, it suggests that the “unlined disposal lagoons” were lined at some point, whereas they were simply abandoned in favor of new, lined lagoons. Suggest deleting “former” and inserting at the beginning of the sentence the text “From the 1950’s through the early 1980’s, liquid waste...” (or whichever other dates are most appropriate/accurate). This section should also be revised so that it references the existence of the off-site plume.

Response: EPA is correct that, as discussed in the first sentence of the third paragraph in Section 3.1.1 (Site Description), “In 1984, two double-lined HE surface impoundments were installed south of Building 817 to receive all HE process waste water and replace the unlined disposal lagoons.”

Therefore, the last sentence of the second paragraph in Section 3.1.1 was revised to read: “From the mid to late 1950s to 1985, liquid waste generated during machining operations was discharged to unlined disposal lagoons,” for clarification. In addition, the word “former” was removed when referring to the unlined HE rinsewater disposal lagoons elsewhere in this section.

The spatial distribution of contaminants in HEPA ground water, including near the Site 300 boundary and offsite is discussed in Section 6.4.1 (Ground Water Remediation Progress).

7. **Section 3.2, Land and Resource Use, page 14:** The text describes Well 18 as a backup fire suppression well, but does not explain whether this well is interconnected with potable on-site water supply Well 20 or how potential contamination of the potable water system is avoided if it is necessary to use Well 18. For example, if fire suppression supply tanks are typically filled using Well 20, there may be some piping in common, so backflow could result in contamination of the potable water supply system when Well 18 is used. Please revise the text to explain how potential contamination of the potable water supply system is prevented when it is necessary to use backup Well 18.

Response: Site 300 Management indicated that Well 18 and Well 20 have common piping. This is the main reason that LLNL has been pursuing connecting the

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Site 300 water-supply system to Hetch Hetchy water. Monthly sampling is conducted for both wells, and Well 18 has not had a confirmed detection of VOCs since 2002 when TCE was detected at a concentration of 0.3 µg/L, below both the 5 µg/L MCL and 0.8 µg/L State Public Health Goal. VOCs have been detected in Well 18 at a concentration above the MCLs only once in thirty years of monthly monitoring (in 1986). Therefore, there is no potential for contamination of the potable water-supply system.

- 8. Section 3.5.5, Distribution of COCs in Ground Water HSUs, page 17:** The text states, “local ranchers continue to pump water from offsite wells completed in the Tnbs₂ HSU [hydrostratigraphic unit] for domestic use and livestock watering, “but the only supply well discussed in the text and depicted on Figure 3 appears to be GALLO1. The text should discuss each offsite supply well, including the pumping rate and the distance from the LLNL site boundary. In addition, each water supply well should be depicted on site figures that depict the extent of the VOC plume. Please revise the text to discuss each offsite water supply well and include them on site figures.

Response: GALLO1 is the only offsite water-supply well that is currently active near the HE Process Area. According to information provided by the well owner, GALLO1 is pumped at rate of about 10 gallons per minute for short periods of time. The well is located within 50 feet from the Site 300 boundary and its location relative to the Site 300 boundary and VOC plume emanating from the HEPA OU is shown on Figure 5. Well GALLO1 is discussed in Section 3.2 (Land and Resource Use), however, additional information, such as pumping rate and distance to the site boundary, has been added to this text. In addition, remediation efforts to reduce contamination near this well are discussed in Section 6.4.1.2.1 (VOC Concentrations, Distribution, and Remediation).

Other offsite active water-supply wells located south of Site 300 include CON1, CON2, and CDF1, but these wells are located approximately 2,500 feet to the east of the HEPA OU and cross-gradient from the VOC plume emanating from the HEPA. Because these wells are located outside of the HEPA OU and would not be impacted by the HEPA VOC plume, these water-supply wells are not shown on the HEPA OU base map (Figure 3). These wells are discussed in the GSA Five-Year Review, as they are located downgradient of the GSA OU and VOC plume.

Well GALLO2 is located south of the GSA OU and east of the HEPA OU. This well thought to have been drilled in the 1940s, and is not used as a water-supply well. There is no pump in this well, and it has not been used for many years. No VOCs have ever been detected in this well and because this well is not being pumped, it is not expected to have any future impact on any nearby VOC plumes. As discussed in the response to EPA’s General Comment #3, the offsite

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plume located nearest GALLO2 emanates from Central General Services Area (GSA) dry well pad. Capture zones for this plume are discussed in the recent GSA Five-Year Review report.

- 9. Section 4, Remedial Actions, page 18:** While discussion of system operations and maintenance (O&M) activities appears in Section 4.2, Remedy Implementation, the text does not include a robust discussion of O&M activities, including requirements, activities to date, and problems that may have arisen, as suggested by Appendix E page E-24 of the Guidance. Please revise the Report to provide a section or table that discusses O&M activities and problems that may have arisen.

***Response:* O&M activities are described in detail in the annual and semi-annual Compliance Monitoring Reports. These reports can be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at <http://www-erd/library>. Section 4.3 (System Operations/Operation and Maintenance) was revised to include compliance issues during the review period.**

- 10. Section 4.1, item 2, page 19:** Unclear whether the 2008 final remedy added IC's or just that the description in this item is more complete than the description of the 2001 interim remedy in the "Site Chronology" section (which doesn't mention ICs). Also, it isn't clear what ICs are required as part of the remedy from the description provided, but this should be clear as this is the section describing the remedy (doesn't have to be detailed description, as this can be provided in IC's section).

***Response:* Section 2.9.1.2 of the 2001 ROD included a Risk and Hazard Management Program that presented the administrative and engineering (institutional) controls to be implemented to prevent exposure to contamination. The 2008 ROD Institutional/Land Use Control language was changed based on newer EPA guidance available at the time. The text in Section 4.1, Item 2 was revised to reference Section 4.4 and Table 2 that describe the Institutional/Land Use Controls for the HEPA OU.**

- 11. Section 4.2, HE Compounds in Surface Soil, Subsurface Soil/Rock, and Ground Water, page 21:** The text discusses well W-817-04, stating that extraction was discontinued in December 2007, but then discusses expansion of the well field to include well W-817-2318 and states "Ground water is currently extracted from both wells at a combined flow rate of approximately 1.5 to 2.0 gpm [gallons per minute]." The quoted statement indicates that groundwater is being extracted from well W-817-04, but none of the figures depict a capture zone for this well. Please clarify whether groundwater is being extracted from well W-817-04, and if so, include the capture zone for this well on a figure.

***Response:* Ground water is not being extracted from well W-817-04. Extraction from this well was, in fact, discontinued in December 2007 due to the low yield. Currently, ground water is extracted from two wells at the 817-PRX treatment**

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facility: W-817-03 and W-817-2318 at a combined flow rate of approximately 1.5 to 2 gallons per minute. The text in Section 4.2 (Remedy Implementation) was revised accordingly.

12. Section 4.4, Institutional Controls:

- a. Like the other Site 300 FYRs reviewed this FY, the HEPA FYR uses the term ICs, but not in the sense that EPA uses the term. Per EPA's IC's Guidance (November 2010 Interim Final version): "EPA defines ICs as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. ICs are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Some common examples of ICs include zoning restrictions, building or excavation permits, well drilling prohibitions, easements, and covenants. ICs are a subset of Land Use Controls (LUCs). LUCs include engineering and physical barriers, such as fences and security guards, as well as ICs." Although the Guidance further notes that "[t]he federal facility program may use either term in its decision documents," seemingly suggesting that either term will do, the best, and recommended, practice is to use the term IC's to refer to non-engineering controls and LUC when referring to a broader universe of controls that includes such things as fencing and security guards. The IC's Guidance should be reviewed to ensure clarity in the use of these terms.

***Response:* Section 4.4 (Land Use Controls) was revised to be consistent with the EPA guidance.**

- b. Page 23, Paragraphs 2 and 3: Both use the future tense ("will") to describe the implementation/performance of the IC's. As this is not the first FYR for the HEPA OU, and the implementation/performance of the ICs presumably is well underway (even if not fully satisfactory), the description should use the present tense (paragraph 2, "are implemented and maintained"; paragraph 3, "DOE reviews").

***Response:* Section 4.4 (Land Use Controls) was completely revised. Therefore, this comment no longer applies. (Note: the description of ICs in the new revised text in Section 4.4 uses the present tense when discussing ICs that are currently being implemented.)**

- c. Page 23, paragraphs 4 and 5: The narrative text should include more information about: 1) in paragraph 4, the ICs inspection; and 2) in paragraph 5, the mechanisms by which the ICs are implemented and maintained.

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Response: Section 4.4 (Land Use Controls) was completely revised to include more information on the implementing mechanisms and the annual Land Use Control Inspection.

- d. The discussion of ICs in the context of property transfer should reference the statutory requirement for the inclusion of deed restrictions in property transferred with contamination remaining on-site.

Response: Section 4.4.2.6 (Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools) was added to the Draft Final Five-Year Review. This text states that: “In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations, Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Record of Decision (ROD).”

- e. The ICs discussion should clearly articulate the basis for ICs in the ROD.

Response: New Section 4.4.1 (HEPA OU Land Use Control Objectives) includes the basis for Land Use Controls (i.e., the risk drivers and land use control objectives for the HEPA OU land use controls).

- f. There is no discussion of the off-site plume or any IC to prevent exposure in relation to it, even though the text in Section 3.5.5 notes that off-site water-supply wells in proximity to the Site are in use.

Response: Section 4.4 (Land Use Controls) was revised to include discussion of the offsite plume and ICs to prevent exposure. Specifically, new Section 4.4.2.2 (Prevent Offsite Water-supply Use/consumption of Contaminated Ground Water) discusses the offsite plume in relationship to water-supply well GALLO1 and the proposed institutional controls to prevent the ingestion of contaminated offsite ground water.

13. Section 5.2, Recommendations and Follow-Up Actions: Item 2 indicates that the IC referenced in the “Summary Form” Protectiveness Statement was not included until 2008 Final Site-Wide ROD.

Response: The institutional control recommendation in Item #2 of Section 5.2 from the 2007 HEPA Five-Year Review was based on discussions with EPA regarding new EPA guidance available at that time. As discussed in the responses to EPA’s Comment #10, the 2008 ROD Institutional/Land Use Control language was changed based on newer EPA guidance available at the time.

14. Section 6.4.1.2.1, VOC Concentrations Distribution, and Remediation, Tnsb₂ HSU, page 29: The second sentence of the section states that the first

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semester 2011 maximum total VOC concentration was 40 micrograms per liter ($\mu\text{g/L}$) in well W-818-08, but Figure 14 appears to indicate that the maximum concentration is in well W-818-11. Please resolve this apparent discrepancy.

Response: Figure 14 shows the distribution of total VOCs in the Tnbs₂ HSU during the second semester 2010. During that time period, the maximum concentration was 62 $\mu\text{g/L}$ in monitor well W-818-11. However, because DOE/LLNL included a discussion of data from the most recent sampling event (first semester 2011), the text and figures describe slightly different time periods. As described in the text, the maximum concentration sampled in the Tnbs₂ HSU during the first semester of 2011 was 40 $\mu\text{g/L}$ in extraction well W-818-08. The text has been revised to clarify the differences in maximum VOC concentrations shown on Figure 14 and discussed in the text in Section 6.4.1.2.1.

15. Section 6.4.1.2.1, VOC Concentrations Distribution, and Remediation, Tnbs₂ HSU, page 31: The text states that Figure 16 indicates that the overall “extent of VOC contamination in Tnbs₂ ground water has not changed significantly except near the southern end of 832 Canyon, ‘but the extent of the highest concentration portion of the plume (i.e., concentrations greater than 50 $\mu\text{g/L}$) in the vicinity of well W-818-11 has expanded. Please revise the text to acknowledge that the highest concentration area of the plume has expanded.

Response: The text in Tnbs₂ HSU subsection of Section 6.4.1.2.1 was revised for clarification as follows: “Overall, the extent of VOC contamination in Tnbs₂ ground water has not changed significantly except near the southern end of Building 832 Canyon where the spatial distribution of total VOCs appears to have increased due to the presence of an additional contouring location, extraction well W-830-2216. Nevertheless, the area of highest concentrations north of 815-PRX has expanded as the plume moves towards extraction wells W-818-08 and W-818-09. Although the outer extent of the VOC plumes in the HEPA did not decrease significantly, the total VOC concentrations within the plumes generally continue to decline.”

16. Section 6.4.1.2.2, HE Compound Concentrations, Distribution, and Remediation, Tnbs₂ HSU, page 32: Although the text states that the extent of the RDX contaminant plume “has not changed significantly during the past five years,” Figure 23 indicates that this plume has expanded laterally and elongated. In addition, the 2010 map has a hotspot in the vicinity of well W-815-1918 with concentrations above 100 $\mu\text{g/L}$ that was not present in 2005. Please revise the text to acknowledge the expansion of this plume.

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Response: The text in Tnbs₂ HSU subsection of Section 6.4.1.2. was revised for clarification as follows: “The lateral extent of RDX contamination in the Tnbs₂ HSU has not changed significantly during the past five years; however, concentrations in monitor well W-809-03 have increased due to the injection of groundwater into nearby well W-815-1918. As shown on Figure 23, an area of higher concentrations is also visible near well W-815-1918 as a result of injection into this well.”

As shown on Figure 23 and discussed above, the injection of treated ground water in W-815-1918 has mobilized RDX in this area.

17. Section 6.4.2, Risk Mitigation Remediation Progress page 40, 2nd paragraph:
The following comments address the discussion of risk in Section 6.4.2:

- a. The document states that: “This concentration is significantly below the air concentration of 0.5 µg/m³ being protective at 10⁻⁶ cancer risk level and 2 µg/m³ being protective of non-cancer effects for residential exposure. The industrial exposure levels are 3 µg/m³ and 8.8 µg/m³ for a 10⁻⁶ cancer risk level and non-cancer effects, respectively.”

This language should be revised as follows:

“This concentration is significantly below the air concentration of 0.43 µg/m³ being protective at 10⁻⁶ cancer risk level and 2 mg/m³ being protective of non-cancer effects for residential exposure. The industrial exposure levels are 3 µg/m³ and 8 µg/m³ for a 10⁻⁶ cancer risk level and non-cancer effects, respectively.”

Response: The text in Section 6.4.2 has been revised to include the correct screening level concentrations that are protective of human health under residential and industrial exposure scenarios as follows: “This concentration is significantly below the air concentration of 0.43 µg/m³ being protective at 10⁻⁶ cancer risk level and 2.1 µg/m³ being protective of non-cancer effects for residential exposure. The industrial exposure levels are 3 µg/m³ and 8.8 µg/m³ for a 10⁻⁶ cancer risk level and non-cancer effects, respectively.

- b. The first paragraph on this page discusses the updated risk calculations using the updated toxicity values for trichloroethene (TCE); however, the units for the cancer inhalation unit risk (IUR) and noncancer Reference Concentration (RfC) are not stated. In addition, the RfC is stated as 2.0 x 10⁻⁶ (no units) and 2.0 x 10⁻³ µg/m³ within this section. Include units for the toxicity values and ensure that the units for the applicable toxicity values are consistent through the discussion.

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Response: The Reference Concentration (RfC) for TCE is $2.0 \times 10^{-3} \text{ mg/m}^3$. The units for the Cancer Inhalation Unit Risk (IUR) are $(\mu\text{g/m}^3)^{-1}$. The text in Section 6.4.2 was updated to include these units.

18. Section 7.2, Changes in Exposure Pathways, Toxicity, Cleanup Levels, and Remedial Action Objectives, page 42: This section states. “There have been no changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question;” however, there have been changes in the federally- and state-promulgated classification of contaminants of concern (COCs), updates to relevant toxicity values for some of the COCs, as well as updated federal risk assessment guidance pertaining to inhalation exposure. The following comments pertain to updates in toxicity information and risk assessment guidance that should be considered in the evaluation of whether the remedy remains protective of human health and the environment in the Five-Year Review.

- a. The EPA has released updated toxicity values for several chemicals within the timeframe of the Five-Year review from September 2006 through September 2011. For example, in addition to TCE, toxicity values were updated for cis-1,2-dichloroethylene (cis-1,2-DCE) in September 2010 (http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=0418). Any changes in toxicity values that can impact the baseline risk calculations need to be evaluated in order to determine whether the remedy remains protective of human health. Further, it is also important that the annual Compliance Monitoring Reports incorporate the most current toxicity information for chemicals when monitoring risks associated with the ongoing remediation of VOCs in the subsurface.

Response: DOE/NNSA have followed all the updates to toxicity values and updates to vapor intrusion guidance for constituents that were under evaluation between September 2006 and September 2011. Risk and hazard management is conducted in areas of Site 300 where the exposure point risk exceeded 1×10^{-6} or the hazard index exceeded 1 in the baseline risk assessment. According to the baseline risk assessment at Building 815, TCE and PCE were the only COCs that exceeded these standards. Cis-1,2-DCE at Building 815 did not exceed these standards in the baseline risk assessment. During the five-year time period from September 2006 to September 2011, there were no COCs at Building 815 with an unacceptable vapor inhalation risk in outdoor ambient air. As described in the 2004 Annual CMR, the vapor inhalation risk in outdoor ambient air at Building 815 for TCE and PCE were no longer considered unacceptable after 2004 (Dibley, et. al., 2005).

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- b. The EPA has issued supplemental guidance for inhalation risk assessment at Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites (EPA, 2009), yet this section does not address changes in risk assessment guidance or methodology that may affect the human health risk estimates. The impact of the change in process for estimating inhalation exposure and risk should be evaluated to determine whether the remedy remains protective of human health.

Please perform the evaluation of changes in exposure pathways, toxicity values, and other contaminant characteristics in accordance with Section 4.2.2, 4.2.3, and Appendix C of the Guidance (EPA, 2001).

Response: Sections 6.4.2 and 7.2 acknowledge that the EPA released updated toxicity values and contaminant characteristics for several constituents. The impact of this change is documented in these sections. All updated EPA guidance regarding exposure pathways were followed.

19. **Section 9, Recommendations and Follow-Up Actions, page 44:** Item 3, the evaluation of Tnbs₂ HSU monitoring well W-815-2621 as an extraction well, does not appear to have a scheduled date of completion. Please provide estimated date of completion for all recommendations and follow up actions.

Response: Completion dates for the recommendations were added to the new Summary Form. Section 9 was also revised to include a completion dates for the recommendation, including recommendation (item) #3.

20. **Table 2 Description of institutional/land use controls for the High Explosives Process Area Operable Unit:**

- a. There is no mention of an off-site plume or IC's to prevent exposure.

Response: Table 2 has been revised to discuss the IC for the offsite plume.

- b. The text uses the future tense even though the referenced IC's already have been implemented.

Response: It is true the ICs have already been implemented, however, these ICs will continue to be performed. For example, "DOE will conduct annual risk re-evaluations when water is present in Spring 5 to determine when the inhalation risk has been mitigated."

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- c. To clarify the protocols/procedures for IC implementation the FYR should include an organizational chart as well as a narrative description of the protocols/procedures.

Response: Section 4.4 has been revised and includes new text that describes the procedures for implementing the institutional/land use controls. The organizations (i.e., the Environmental Restoration Department) or entities (i.e. Work Induction Board) referenced in Table 2 are discussed in the context of the screening and flow of proposed work/activities at Site 300 through a work control process that is set up and implemented to ensure that the work is conducted in accordance with institutional and regulatory requirements, as applicable. As such, it does not reflect a hierarchy of authority within the LLNL organization that can be shown on an organizational chart. For example, the Work Induction Board is typically comprised of individual from various organizations at LLNL that have specific knowledge and expertise with which they can help determine if proposed work/activity can be conducted within the framework of institutional and regulatory requirements. The Board consults with Environmental Restoration Department (ERD) when the proposed work/activities may be impacted by or have impact to environmental factors (i.e., soil or ground water contamination) under ERD's purview.

- d. The second listed IC states (in the third column) that "activities must be cleared through the LLNL Work Induction Board", but it does not specify the basis of the requirement. The institutional framework also should be clarified in terms of the relationship and hierarchy of authority of the multiple entities identified as playing a role in the control of excavation activities.

Response: Section 4.4 has been revised and includes new text that provides additional information on the Work Induction Board and the work review process. Please refer to the response to EPA's Specific Comment #20c above regarding the relationship of the multiple entities (i.e., the Work Induction Board, ERD) that play a role in reviewing proposed work/activities to ensure that they are conducted within the framework of institutional and regulatory requirements, including institutional controls.

- e. The third listed IC notes IC re vapor intrusion (VI) in building 815 no longer needed, but there is no mention of IC for VI in other buildings underlain by the plume.

Response: Please refer to the response to EPA's General Comment #1.

- f. The fifth listed IC should provide for both a SLUC and deed restrictions.

Responses to Regulatory Comments on the Draft Five-Year Review for the High Explosives Process Area OU at LLNL Site 300

Response: The fifth listed IC is codified in the FFA. The FFA prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use without a land use covenant.

21. Figure 8: A site location map should be included that shows the basic OU surface features and identifies Building structures and springs. Figure 8 is the closest to identifying basic OU surface features including the inferred location of Building 815 where the risk from vapor intrusion was evaluated. However, the maps provided do not identify Building locations (including the “medical clinic building” and the “former site cafeteria”).

Response: Figure 3 is a site location map that shows the topography, buildings, lagoons, pits, springs, streams and other surface features that are discussed in the report. Building 815 is identified on Figure 8. The medical clinic building and former site cafeteria are not referred to in the text of this document.

22. Appendix A, Section A-3, Model Description, pages A-2 through A-4: The water budget was not provided. Please provide the water budget.

Response: Recharge and discharge are described in Section A-3.3 (Boundary Conditions, Aquifer Type, Top and Bottom Layers) and in Section A-2.5.1 (Flow Calibration). Recharge to the model of 2,498 cubic feet per day (cfd) was applied through the northern boundary and via areal recharge. As discussed in the text, this flux fell within the range of independent estimates of recharge from 925 to 3,655 cfd that were determined considering the size of the catchment area. The northern boundary represents inflow from the catchment area where the Tnbs₂ stratigraphic units are exposed at the surface and from where narrow canyons intersect with the model boundaries. Areal recharge was applied in the northernmost, unconfined portions of the aquifer and represented approximately 50% of the total flux into the model. Discharge occurred along the southeastern border of the model where the Tnbs₂ HSU sub-crops beneath the Quaternary alluvium. Offsite water supply well GALLO1 was assigned a constant extraction flow rate of 1 gallon per minute (gpm) in some scenarios. This well is typically operated intermittently at higher flow rates, however, a conservative average extraction flow rate was selected to be consistent with long-term observed ground water elevations. Pumping of other offsite water-supply wells (no longer active or abandoned) was not considered.

23. Appendix A, Section A-3.5.1, Flow Calibration, pages A-3 and A-4: In addition to visual inspection, a map depicting positive and negative residual heads (e.g., using different colors for positive and negative residual heads) should be prepared to evaluate whether the model has spatial bias. Please provide this figure and discuss whether the model has spatial bias.

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Response: As discussed in Section A-3.5.1 (Flow Calibration), this model was calibrated by matching ground water elevation data for four different time periods. Figure A-3 shows a comparison of measured and modeled ground water elevation data during the unstressed 1999 time period. The objective of this figure was to visually depict the differences between measured and modeled data during one flow calibration time period. A map showing the positive and negative residual heads has also been provided. As shown on this figure, the model was able to match the general pattern of ground water elevations, with some differences occurring near the model boundaries in the area north and south of the low permeability fault zone.

24. Appendix A, Section A-3.5-2 Transport Calibration, page A-4: A map depicting the modeled and actual contaminant plumes should be provided to substantiate the statements in this section. Please include a map depicting the modeled and actual contaminant plumes.

Response: A figure showing the results of the transport calibration where a source term of 0.0025 mg/L was applied for 25 years and then allowed to migrate for another 30 years is attached to these responses. As discussed in the text, the model was primarily calibrated using ground water elevation data. The model was able to match the general plume shape and concentration distributions in some portions of the Tnbs₂ HSU. Nevertheless, using a single point source, the model was not able to match TCE concentrations near the site boundary. This suggests that another source, probably located in the Building 832 Canyon OU, may have contributed to the TCE plume in this area. Intermittent pumping at onsite and offsite water supply wells such as GALLO1 have also impacted the spatial distribution of TCE in the Tnbs₂ HSU, however, detailed pumping histories for these wells are not available. As a result, a closer match between the measured and modeled concentration data is not likely using a steady-state flow model.

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Regional Water Quality Control Board (RWQCB)-Central Valley Region Comments on the Draft Five-Year Review for the High Explosives Process Area at LLNL Site 300

GENERAL COMMENTS

1. The Draft 5-Year Report needs to summarize compliance records for discharge requirements of treated groundwater during the five-year review period. The text also needs to summarize any non-compliance that occurred and discuss the mitigation measures that were implemented. Also see Specific Comment No. 5b below.

Response: Section 4.3 (System Operations/Operation and Maintenance) was revised to include a summary of compliance issues that occurred during five year review period. Treatment system discharge compliance is discussed in detail in the annual and semi-annual Compliance Monitoring Reports (CMRs). These reports can be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at <http://www-erd/library>.

2. All site physical features discussed in the text need to be shown on a figure. Reference to this figure should be made when these physical features are discussed in the text. Also see Specific Comments No. 1a and 5b below.

Response: Figures 3 and 8 have been updated to include physical features referenced in the text.

3. The Draft 5-Year Report needs to include discussion that explicitly states whether any contaminants of concern (COCs) have ever been detected above their respective maximum contaminant levels (MCLs) in any of the sentry wells. The Draft 5-Year Report also needs to outline the steps that would be taken in the event the contaminant plume migrates offsite, or reference the document that defines the response actions.

Response: During the past five years, COCs have not been detected above MCLs in any HEPA OU guard wells (W-815-2110, W-815-2111, W-35B-01, W-35B-02, W-35B-03, W-35B-04, W-35B-05, W-6H, W-6J, W-4C, W-880-01, W-880-02, W-880-03 and W-814-04). However, in the past and during the five-year review period, COCs (primarily TCE) have been detected in guard wells at concentrations above the 0.5 µg/L reporting limit, but below MCLs, on a sporadic basis. Historically, the only VOC other than TCE detected at concentrations above MCLs was vinyl chloride (0.8 µg/L in W-35B-04 in October 2000 and 0.9 µg/L in W-35B-05 in October 2000). The California MCL for vinyl chloride is 0.5 µg/L.

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Section 6.4.1.2, has been revised to include this discussion. In addition, Section 4.4 (Institutional Controls) has been revised to include steps that will be taken to prevent the private property owner from drilling water-supply or agricultural wells in the offsite portion of the plume above cleanup standards. Section 10.1.1.3 of the Compliance Monitoring Plan/Contingency Plan describes steps taken if there are impacts to guard wells.

4. The Draft 5-Year Report is missing figures for time-series plots and distribution of COCs such as nitrate and High-Melting Explosive (HMX) in groundwater. The Draft 5-Year Report needs to either provide the figures or explain why these figures are not included.

Response: Time-series plots and the distribution of COCs are not shown for all COCs because the concentration trends and distribution patterns for these COCs are similar to the plots shown. For example, in the Tnbs₂ HSU the distribution of HMX falls within the footprint of the RDX plume shown in Figure 23. The HMX concentration trends over time have been added to Figures 15 (c) and 24 (b). Distributions of nitrate are shown in Figures 20, 28, and 29. Because the remedy for nitrate is monitored natural attenuation, nitrate concentrations decrease as ground water moves from the unconfined to confined portions of the Tnbs₂ HSU, where natural denitrification reduces nitrate concentrations to background levels. As a result, time-series plots of nitrate concentrations in individual wells do not reflect the remediation via MNA and therefore are not presented for nitrate.

SPECIFIC COMMENTS

1. Page 12, Section 3.1.1, Site Description:

- 1a. Several site features are discussed without reference to a figure for their locations. The Draft 5-Year Report needs to include references to the appropriate figure(s) for the location of the High Explosives (HE) Burn Pit, former disposal lagoons, former surface impoundments, Buildings 806, 807, 810, 815, 817, and 829, the former dry well at Building 810, and the former drum rack near Building 815.

Response: Figure 3 has been updated to include site features referenced in the text.

- 1b. The last sentence of the fourth paragraph states that three deep groundwater wells were installed in the regional Tertiary Neroly Lower Blue Sandstone (Tnbs₁) aquifer for post-closure monitoring of the HE Burn Pit facility. The Draft 5-Year Report needs to specify which three deep groundwater wells it is referring to.

Response: The three wells that were installed in the Tnbs₁ aquifer for post-closure monitoring of the HE Burn Pit facility are W-829-15, W-829-22 and

Responses to Regulatory Comments on the Draft Five-Year Review for the High Explosives Process Area OU at LLNL Site 300

W-829-1938. The locations of these wells are shown on Figure 3 and Section 3.1.1 was revised to include the well names.

1c. The first sentence of the fifth paragraph states that twelve confirmed chemical release sites have been identified in the HEPA OU. However, Regional Water Board staff's tally includes nine former disposal lagoons as shown on Figure 3, along with the former drum rack and the former dry well, for a total of eleven sites. Clarify the identity of the twelve sites.

Response: The thirteen confirmed chemical release sites in the HEPA OU are the ten former disposal lagoons, the former drum rack, the former dry well and the former unlined disposal lagoons at HE Open Burn Pit Facility. The text in Section 3.1.1 has been changed to reflect this information and these release sites are now all shown on Figure 3.

2. Page 13, Section 3.1.2.2, Saturated Zone, Quaternary Alluvium Hydrostratigraphic Unit (Qal HSU): The second sentence states that "It ranges up to 35 feet in total thickness." It is not clear what the minimum thickness of the Qal HSU is. Revise the sentence to indicate the minimum thickness of the Qal HSU.

Response: The saturated thickness of the Qal HSU ranges from 0 to 35 feet. Section 3.1.2.2 has been updated to include this information.

3. Page 14, Section 3.2, Land and Resource Use:

3a. The fourth paragraph states that the lower pumping rates at Well 20 are not expected to impact groundwater flow and contaminant transport in the Tertiary Neroly Upper Blue Sandstone (Tnbs2) HSU because Well 20 is not completed in this interval. Please indicate what the pumping rates are.

Response: Onsite water-supply Well 20 is pumped intermittently on an as-needed basis. Historically, pumping rates at Well 20 have ranged from less than 30 gallons to per minute to over 60 gallons per minute, however, the well is not operated continuously. Section 3.2 was revised to include Well 20 pumping rate information.

3b. The 2008 Annual Compliance Monitoring Report identified the need for a review for the chloride in Spring 14. Please clarify whether the review was completed and what actions were completed for the review. Also, please revise the subsequent sentence which reads "An LLNL ecologists reviewed ecological data collected between 2008 and 2011 for the HEPA area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors." The sentence is grammatically incorrect and does not make sense.

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Response: Spring 14 chloride concentrations were discussed in the 2010 Annual CMR as follows: “Although the maximum chloride concentration detected in Spring 14 exceeds the maximum concentration observed in background springs, the chloride concentration in the most recent sample collected from Spring 14 was below the maximum concentration detected in the background springs. Chloride concentrations will be monitored in future samples collected from Spring 14.” This monitoring is ongoing. The text in Section 3.2 was revised to include this information.

The sentence in question was revised as follows: “An LLNL ecologist reviewed the HEPA ecological data collected between 2008 and 2011 to evaluate whether any changes in contaminant or ecological conditions were present that could impact ecological receptors.”

3c. The last sentence of the fourth paragraph states that access to the unique animal and plant populations is controlled. Please describe how access is controlled.

Response: All activities conducted at Site 300 are reviewed by the Site 300 biologist to evaluate the potential for impacts to species of special concern. The text was revised to include this information.

Where potential impacts to species of special concern are identified, the biologist may specify:

- Seasonal limitations to areas where work can be conducted to avoid migrating species.
- Engineered controls (i.e., temporary fencing/covers to prevent species access to areas where they could be harmed [e.g., mud pits, holes]).
- Training for workers in the identification and avoidance of this species if they are encountered in the field.
- Consultation with the U.S. Fish & Wildlife Service.

4. Page 17, Section 3.5.5. Distribution of COCs in Groundwater HSUs: The first paragraph states that most groundwater contamination at the HEPA OU occurs in the Tnbs₂ HSU. It also states that local ranchers pump water from offsite wells completed in the Tnbs₂ HSU for domestic use and livestock watering. Please clarify the locations of the offsite wells in relation to the contaminant plume at the HEPA OU, and specify if they are located upgradient, downgradient, or crossgradient from the plume. Also specify the contingency plan in the event of offsite migration of contamination or detection of COCs above MCLs in the sentry wells.

Response: As shown on Figure 14, offsite water-supply well GALLO1 is the located downgradient and to the west of the VOC plume emanating from the HEPA OU in the Tnbs₂ HSU. Other offsite active water-supply wells located south of Site 300 include CON1, CON2, and CDF1, but these wells are located

Responses to Regulatory Comments on the Draft Five-Year Review for the High Explosives Process Area OU at LLNL Site 300

approximately 2,500 feet to the east of the HEPA OU and cross-gradient from the VOC plume emanating from the HEPA. Because these wells are located outside of the HEPA OU and would not be impacted by the HEPA VOC plume, these water-supply wells are not discussed in the HEPA Five-Year Review. These wells are discussed in the GSA Five-Year Review, as they are located downgradient of the GSA OU and VOC plume.

Well GALLO2 is located south of the GSA OU and east of the HEPA OU. This well is thought to have been drilled in the 1940s, and is not used as a water-supply well. There is no pump in this well, and it has not been used for many years. No VOCs have ever been detected in this well and because this well is not being pumped, it is not expected to have any future impact on any nearby VOC plumes. As discussed in the response to EPA's General Comment #3, the offsite plume located nearest GALLO2 emanates from Central General Services Area (GSA) dry well pad. Capture zones for this plume are discussed in the recent GSA Five-Year Review report. Section 3.5.5 was revised to include this information.

Section 4.4 (Institutional Controls) has been revised to include steps that will be taken to prevent the private property owner from drilling water-supply or agricultural wells in the offsite portion of the plume above cleanup standards. Section 10.1.1.3 of the Compliance Monitoring Plan/Contingency Plan describes steps taken if there are impacts to guard wells.

5. Page 20, Section 4.2, Remedy Implementation:

5a. The fifth sentence in the fifth paragraph contains a typographical error. Please revise the sentence.

Response: The sentence was changed to, "As part of this upgrade, monitor wells W-815-2111 and W-815-2110 and all extraction wells will be outfitted with pressure transducers and added to the treatment facility real-time monitoring system (TFRT).

5b. The last sentence of the fifth paragraph states that treated effluent is discharged to an infiltration trench. Please show the location of this infiltration trench on the site map. Also, state whether this discharge has been compliant with requirements for discharge of treated groundwater during the five-year review period. If any non-compliance occurred, discuss the mitigation measures that were implemented.

Response: Figure 3 has been updated to show the location of the 815-DSB infiltration trench.

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As discussed in the response to the RWQCB's General Comment #1, Section 4.3 (System Operations/Operation and Maintenance) was revised to include a summary of compliance issues during the five year review period. Each CMR contains a compliance summary for treatment facilities in the HEPA OU, including information about discharges to the 815-DSB infiltration trench. As noted in these reports, the 815-DSB treatment facility operated in compliance with the RWQCB Substantive Requirements for Wastewater Discharge during the five year review period.

6. Page 28, Section 6.4.1.2.1, VOC Concentrations, Distribution, and Remediation: The last sentence of the first paragraph states that 1,2-DCA was detected in W-814-01 at 0.75 µg/L and in W-814-2138 at 0.8 µg/L. Please state when these concentrations were detected.

Response: On March 9, 2011, 1,2-DCA was detected in well W-814-01 in two samples (routine and duplicate) at concentrations of less than or equal to 0.8 µg/L and in one sample collected from well W-814-2138 at 0.8 µg/L. The last sentence of the first paragraph in Section 6.4.1.2.1 was revised to include this information.

7. Figure 3: The figure contains too much detail for the size of the figure. Please consider printing the figure on 11"x17" paper for clarity. Also, correct the typographical error (for topographic contour) in the legend.

Response: A larger (11"x 17") figure was included in the Draft Final HEPA Five-Year Review.

8. Figure 13: Please revise the figure to show the area influenced by the hydraulic injection from injection well W-814-2134.

Response: The area influenced by hydraulic injection from injection well W-814-2134 was not shown on Figure 13 because the 815-PRX treatment facility was not operating during the second semester 2010. The 815-PRX treatment facility was operating during the first semester 2010 and as a result, the area of hydraulic influence from injection well W-814-2134 is shown on Figure 14. This hydraulic influence area was drawn using the first semester 2010 water level data.

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California Department of Toxic Substances Control (DTSC) Comments on the Draft Five-Year Review for the High Explosives Process Area at LLNL Site 300

1. Five-Year Review Summary Form, Recommendations and Follow-up Actions – Please be more specific on the schedules for items 1-6.

Response: The Draft Final Five-Year Review includes the new EPA Summary Form that includes milestone dates.

2. Section 4.4, Institutional Controls – The second to the last paragraph states that DOE distributed a Memorandum to the Administrative File on March 13, 2007. Please attach the memorandum to this report.

Response: Section 4.4 was completely revised based on EPA Five-Year Review comments. As result, the reference to the “Memorandum to the Administrative File that DOE distributed on March 13, 2007” is no longer contained in Section 4.4. Therefore, the memorandum was not attached to the report.

3. Section 9, Recommendations and Follow-up Actions – Please be more specific on the schedules for items 1-6.

Response: The schedules for implementation of Recommendations (Items) 3, 6, and 7 were added to Section 9 (Recommendations and Follow-up Actions). Schedules for the implementation of Recommendations (Items) 1, 2, 4, and 5 were already included in Section 9.

4. Figure 8 – It is not clear how Figure 8 shows the specific area of the HEPA OU where institutional/land use controls will be implemented and maintained. Please clarify.

Response: Figure 8 was included in the Record of Decision and Compliance Monitoring Plan/Contingency Plan to depict where prohibitions exists for excavation and water supply well drilling onsite. No excavation is allowed without additional controls in the area surrounded by the dashed line. No water-supply wells are to be drilled in the darkened area representing the extent of contamination in ground water with concentrations above background. Please see Table 2 and Section 4.4 for additional information on Institutional Controls.

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Tri-Valley Communities Against a Radioactive Environment (TVC) Comments on the Draft Five-Year Review for the High Explosives Process Area at LLNL Site 300

1. Since the High Explosives Process Area Operable Unit is part of the Site Wide Remedy, Remedial Action Objectives (RAOs) should be the same as those in the Site-Wide Record of Decision (ROD). There are a few RAOs that are not identified in the Draft Five-Year Review that are in the ROD. Please correct.

Response: Section 4.1 states, “The remedy selected for the HEPA OU is intended to achieve the following Remedial Action Objectives (RAOs):...” Therefore, the Five-Year Review only references those RAOs that are applicable to the HEPA remedy. For example the RAO: “Prevent human inhalation of contaminants bound to resuspended surface soil particles that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4} , or a cumulative hazard index (all noncarcinogens) greater than 1.” is not applicable to the HEPA remedy as there is no surface soil contamination to be addressed by the remedy. The HEPA Five-Year Review is correct as is.

2. We agree that additional capture wells are necessary to offset the effect of intermittent pumping at the off-site Gallo Well 1.

Response: Comment noted.

3. Additional consideration should be given to risk mitigation from the inhalation pathway (6.4.2). EPA Region 9 toxicologists have recommended an industrial removal action level (RAL) for TCE of 15 microgram per cubic meter (mg/cm) at another site in the Bay Area. This RAL is based on non-cancer health endpoints in the latest Toxicological Evaluation released in September 2011. Specifically, it was shown that TCE has teratogenic effects on fetal heart development during 21 days in the first trimester of pregnancy. It is important to mention this and implement protective actions while EPA headquarters is trying to resolve differences among various parties and Region 9 concerning this RAL. While the other site is indoors, and the site at the HEPA OU is ambient around Spring 5, this “draft” RAL should be taken into consideration when developing a risk mitigation strategy. And because the Toxicological Evaluation is based in part on animal studies, it is important to carry this over to the ecological risk assessment.

Response: The September 2011 TCE toxicity value was discussed in Section 6.4.2. Currently, this change is only expected to significantly impact the assessment of risk for the vapor inhalation pathway. The inhalation risk was reassessed with the new value and no unacceptable risks were calculated. There has not been water at Spring 5 since 2003, therefore inhalation risk cannot be re-evaluated,

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however, since there is no water, there is no ecological risk. In addition, no special status species are present in the area.

Comment Responses for the Draft Final Five-Year Review Report for the High Explosives (HE) Process Area Operable Unit (OU) at Lawrence Livermore National Laboratory (LLNL) Site 300

U.S. Environmental Protection Agency (EPA) Comments:

EPA Draft Final Comment 1: Response to General Comment 1: EPA appreciates that the Lab incorporated the new Summary Form into the draft final document. However, EPA believes the seven recommendations cited are actually optimization measures (i.e. issues which do not directly impact remedy protectiveness, and should not be included as Five-Year Review protectiveness issues).

Response: As indicated in the U.S. Department of Energy's (DOE) response to EPA's Specific Comment 2c on the Draft HE Process Area Five-Year Review, DOE is the lead agency for the LLNL Site 300 cleanup and therefore, the Five-Year Review is a DOE document. As such, the Five-Year Review Summary Form provides a useful tool to identify recommended additional scope of work to optimize cleanup in the OU for DOE management and to support funding requests. For this reason, the recommendations were not removed from the Summary Form. It is stated in the Summary Form that these recommendations do not affect the protectiveness of the remedy, providing EPA with the necessary justification not to include and track them in the EPA database.

EPA Draft Final Comment 2: Specific Comment (SC) 2b: The responses partially address the comments with respect to potential vapor intrusion issues. Additional information is needed to support the statement that "a direct pathway is not present that would allow VOCs [volatile organic compounds] to be transported in the vapor phase from the Tnbs2 HSU [hydrostratigraphic unit] through the vadose zone to the groundwater surface or into buildings in these areas." For example, the depth to groundwater and the thicknesses of the low permeability confining layer and overburden soil are needed to justify the quoted statement. In addition, the justification should include the type(s) of soil present in overburden, whether there are fractures in the confining layer, and VOC concentrations in groundwater beneath these buildings.

Response: As discussed in DOE's response to EPA's General Comment 1 and 2, the Tnsc₂ siltstone/claystone is a low-permeability confining layer that overlies the Tnbs₂ hydrostratigraphic unit (HSU) in which VOC contamination is present in ground water.

EPA expressed a VOC inhalation concern in their General Comment 1 and Specific Comment 2b for the vicinity of two buildings (Buildings 889 [Medical

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Center] and 880 [former cafeteria]). The following conditions exist in the vicinity of Buildings 889 [Medical Center] and 880 [former cafeteria]):

- The Tnsc₂ siltstone/claystone low-permeability confining layer that overlies the Tnbs₂ HSU is approximately 50 to 75 feet (ft) thick.
- The top of the Tnbs₂ stratigraphic unit is approximately 100 to 125 feet below ground surface.
- Approximately 50 to 75 ft of Tnsc₂ siltstone/claystone, 35 ft of Tpsg-Tps sands/gravel, and 15 ft of Quaternary terrace deposits overlie the top of the Tnbs₂ HSU.
- Ground water occurs under confined (and often flowing artesian) conditions in the Tnbs₂ HSU, which demonstrates the competency of the confining Tnsc₂ low-permeability layer in this area. As a result, there is no direct pathway for VOCs in soil vapor to migrate from the Tnbs₂ HSU to the surface. Vapor would have to migrate through the Tnsc₂ confining layer primarily via diffusion as the competency of this layer suggests that few, if any, fractures are present in the Tnsc₂ confining layer. Johnson-Ettinger modeling indicates that no unacceptable vapor inhalation risk is present in the area. This is primarily due to the thickness and low permeability of the confining layer and overlying soil and the relatively low VOC concentrations in ground water in this area. This modeling was very conservative, because it was assumed that VOCs in the Tnbs₂ HSU were able to breach the Tnsc₂ confining layer, which is unlikely given the integrity and thickness of the Tnsc₂ confining layer in the area.
- VOC concentrations in ground water monitor wells in the area (W-4A, W-4B, W-880-01, W-6K, W-6L, W-6ER, W-815-2621 and W-35C-04) are relatively low, and consist primarily or entirely of trichloroethylene (TCE). The maximum historical VOC concentration in these wells was 36 µg/L (2001 [W-6L]), which consisted entirely of TCE; the current maximum concentration is 23 µg/L.

EPA Draft Final Comment 3: Response to SC 2d: Recommendation #7 - Given that the issue is described in part as a remedy integrity issue (i.e., the plume is being pulled further off-site), EPA believes that the recommendation should address remedy integrity, or to explain contingencies to address increasing concentrations in the Gallo1 supply well.

Response: Recommendation #7 identifies potential locations for two additional effluent injection wells to allow 817-Proximal (PRX) wellfield extraction rates to be increased in the Tnbs₂ HSU, and no issue is identified for this recommendation. Therefore, DOE/LLNL assumes that EPA's comment is referring to Recommendation #8 rather than Recommendation #7.

Assuming that EPA is referring to Recommendation #8, this recommendation addresses the issue identified by EPA that offsite institutional controls may not be sufficient to prevent the consumption of contaminated ground water at offsite water-supply well GALLO1 or to prevent the installation of a new water-supply

Responses to Regulatory Comments on the Draft Final Five-Year Review for the High Explosives Process Area OU at LLNL Site 300

wells within the offsite portion of the VOC plume with concentrations above MCL cleanup standards.

The selected remedy was designed in part to address the concern that the pumping of water-supply well GALLO1 might be pulling the VOC plume offsite. As part of the remedy, a ground water extraction and treatment system (815-Distal Site Boundary [-DSB]) was installed and is being operated specifically to prevent further offsite plume migration, including offsetting the effects of pumping of the GALLO1 well.

In addition, DOE/LLNL continues to evaluate the effectiveness of the 815-DSB extraction and treatment system in achieving these goals, and to identify and implement additional measures when necessary to ensure its effectiveness. For example, Recommendation #2 to convert Tnbs₂ HSU monitor well W-815-2608 to an extraction well to increase hydraulic capture and prevent further offsite migration of VOCs is part of this ongoing effort. This recommendation has already been implemented. Therefore, DOE/LLNL does not believe that there is a remedy integrity issue. Contingency actions to address contamination of private water-supply wells are already included in the Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at LLNL Site 300. In addition, Recommendation #8 states that DOE will include a provision in the Memorandum of Understanding with the owner of the GALLO1 well to formally document that DOE will provide point-of-use treatment if VOCs are detected above cleanup standards in this well.

EPA Draft Final Comment 4: Recommendation #8 (Protectiveness Statement) - As used by EPA, a site is defined by wherever contamination has come to be located. So used, this 1st sentence is inaccurate: the remedy is protective in the short term, but not the long term. The text in the last sentence of paragraph 4 references long-term protectiveness, however, the message should appear up front for appropriate context.

Response: DOE assumes that EPA's comment refers to the Protectiveness Statement, rather than Recommendation #8. The 1st paragraph of the Protectiveness Statement has been replaced with the following text: "The remedy at the HE Process Area OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination and remedial treatment systems are effectively treating ground water. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. However, in order for the remedy to be protective in the long-term, institutional controls will be implemented to prevent potential future exposure to offsite ground water contamination."

(2nd paragraph) Same comment as Issue/ Recommendation #7 and remedy integrity.

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Response: Please refer to the above response to EPA's comment on DOE's response to Specific Comment 2d.

(6th paragraph) The FFA (Federal Facility Agreement) is not the source of the requirement, CERCLA 120(h) is; the FFA just references the statutory requirement. The ROD (Record of Decision) does not "prohibit" the transfer of contaminated property; as the remedy decision document, it simply requires that the remedy include proprietary controls. Implementation of the ROD requirement is, on transfer by DOE, through deed restrictions at time of transfer, as well as State Land Use Covenant (SLUC).

Response: The 6th paragraph of the Protectiveness Statement has been modified to state: "Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. The land use control consists of implementing a land use covenant per Title 22 California Code of Regulations (CCR), Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h) in the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future. This land use control requirement is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, EPA, Department of Toxic Substances Control (DTSC), and Regional Water Quality Control Board (RWQCB) agree adequately shows that no unacceptable risk for residential or unrestricted land use is present."

EPA Draft Final Comment 5: Response to SC 7: The response addresses the comment, but the information provided in the response should be included in the HEPA Five-Year Review Report.

Response: The response to EPA's Specific Comment 7 was added to Section 3.2 (Land and Resource Use).

EPA Draft Final Comment 6: Response to SC 10: EPA recommends deleting the clause "will be implemented" so that the description matches the other items.

Response: The second sentence in Item 2, Section 4.1 has been modified to read "Institutional/land use controls to prevent human exposure to contamination and to protect the integrity of the remedy."

EPA Draft Final Comment 7: Response to SC 21 (Figure 8): The revised draft did not address EPA's comment. The maps provided do not identify Building locations (including the "medical clinic building" and the "former site cafeteria")."

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Response: As discussed in the original DOE response to EPA's Specific Comment 21 on Figure 8, Figure 3 is a site location map that shows the topography, buildings (including building numbers), lagoons, pits, springs, streams and other surface features that are discussed in the report. The medical clinic building and former site cafeteria are not referred to in the text of this document, and therefore are not identified by these names on the figure. The medical clinic building and former site cafeteria are Buildings 889 and 880, respectively, and are shown on Figure 3.

EPA Draft Final Comment 8: Response to SC 23: Revise the text to include the information provided in this response and provide the missing figure. The response partially addresses the comment. The map promised in the response was not provided. The response states that a "map showing positive and negative residual heads has also been provided."

Response: The map/figure showing positive and negative residual heads was inadvertently not included with the submittal of the comment responses on the Draft HE Process Area Five-Year Review. The figure has been provided with these comment responses as Attachment 1. The map in Attachment 1 shows the positive and negative residual heads in feet. As shown in Figure A-3 and as indicated in the data depicted in Attachment 1, the model was able to match the general pattern of ground water elevations with some differences near the model boundaries.

EPA Draft Final Comment 9: Response to SC 24: Provide the missing figure. The response partially addresses the comment. The figure promised in the response was not provided. The response states, "A figure showing the response of the transport calibration where a source term of 0.0025 mg/L was applied for 25 years and then allowed to migrate for another 30 years is attached to these responses." However, the responses did not have the referenced attached figure.

Response: The referenced figure showing the response of the transport calibration was inadvertently not included with the submittal of the comment responses on the Draft HE Process Area Five-Year Review. The figure has been provided with these comment responses as Attachment 2.

Additional Comments on New Material:

1. **Five Year Review Summary Form, Recommendation 8, Page v:** Review the milestone date for Recommendation 8 and verify that it is correct. The milestone date for Recommendation 8 is September 28, 2012, which indicates that this recommendation should already have been accomplished. It is unclear if this recommendation was accomplished in September 2012 or if it will be accomplished before the Third HEPA Five-Year Review Report.

Response: DOE sent a letter to owners of the property on which the offsite portion of the HE Process Area OU VOC plume is located to initiate a discussion of

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offsite institutional controls on November 8, 2012. Therefore, the milestone date for Recommendation 8 was changed to reflect this date.

2. **Section 4.4.1 (Land use control objective 5):** Make clear that the prohibition isn't absolute; if clean up to UU/UE (unrestricted use/unrestricted exposure) is not achieved, there must be appropriate ICs in place before the property transfer (i.e., deed restrictions (per CERCLA 120(h) and SLUC per State ARAR).

Response: In Section 4.4.1, land use control objective 5 has been modified to state: **“Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. In the event that Site 300 property with unmitigated contamination that could cause potential harm under residential or unrestricted land use is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations Division 4.5, Chapter 39, Section 67391, and deed restrictions per CERCLA 120(h).”**

3. **Section 4.4.2.1 (Work Induction Board) 2nd paragraph, last sentence, rest of clause beginning with:** ”and are therefore protective...”. This statement is inappropriate and should be deleted. Relevant information to provide would be for example, how many instances of drilling were identified and reviewed.

Response: In Section 4.4.2.1 (Work Induction Board), the 2nd paragraph has been modified to state: **“During this five-year review period, there were no proposals brought to the Work Induction Board to drill and install new onsite water-supply wells within areas of onsite ground water contamination in the HE Process Area OU.”**

4. **Section 4.4.2.3 (Work Induction Board) 1st paragraph.** Insert after LLNL WIB, "and Environmental Restoration Department" 2nd paragraph, last sentence, rest of clause beginning with: ”and are therefore protective...”. This statement is inappropriate and should be deleted. Relevant information to provide would be for example, how many instances of drilling were identified and reviewed.

Response: Please note that Section 4.4.2.3 is related to the control of onsite excavation activities, not drilling as referenced in the comment above. However, in Section 4.4.2.3 (Work Induction Board), the 2nd paragraph has been modified to state: **“During this five-year review period, there were no proposals brought to the Work Induction Board or as part of the dig permit process conduct excavation activities within areas of contamination in the HE Process Area OU.”**

5. **Section 4.4.2.6 (Prohibit Transfer) 1st paragraph.** The FFA is not an IC part of the remedy as it was put in place prior to the ROD, although it does provide that the DOE must comply with CERCLA 120(h), the source of the substantive requirement. Also, as noted elsewhere, the ROD is not an enforcement tool, just the remedy decision

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document. The text should note that at present, LLNL remains an active DOE facility, so ICs required by the ROD are not yet implemented. They will be implemented if and when the property to be transferred is consistent with ROD's requirements. Last paragraph, last line: This is not currently an issue, since the property remains in DOE ownership. Delete text describing protectiveness, as it is not appropriate.

Response: The text in the first paragraph of Section 4.4.2.6 (Prohibit Transfer) has been modified to state: “Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 ROD.”

Other modifications made to Section 4.4.2.6 include:

- **The title of Section 4.4.2.6 has been modified to: “Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls”**
- **The title of the subsection in Section 4.4.2.6 has been changed to “Proprietary Controls Implementation Status.” This subsection has been modified to read:**

“To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 Federal Facility Agreement (FFA) and Site 300 ROD contain provisions that assure DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR, Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Record of Decision (ROD), and will implement deed restrictions per CERCLA 120(h). The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree adequately shows that no unacceptable risk for residential or unrestricted land use is present.

LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions.

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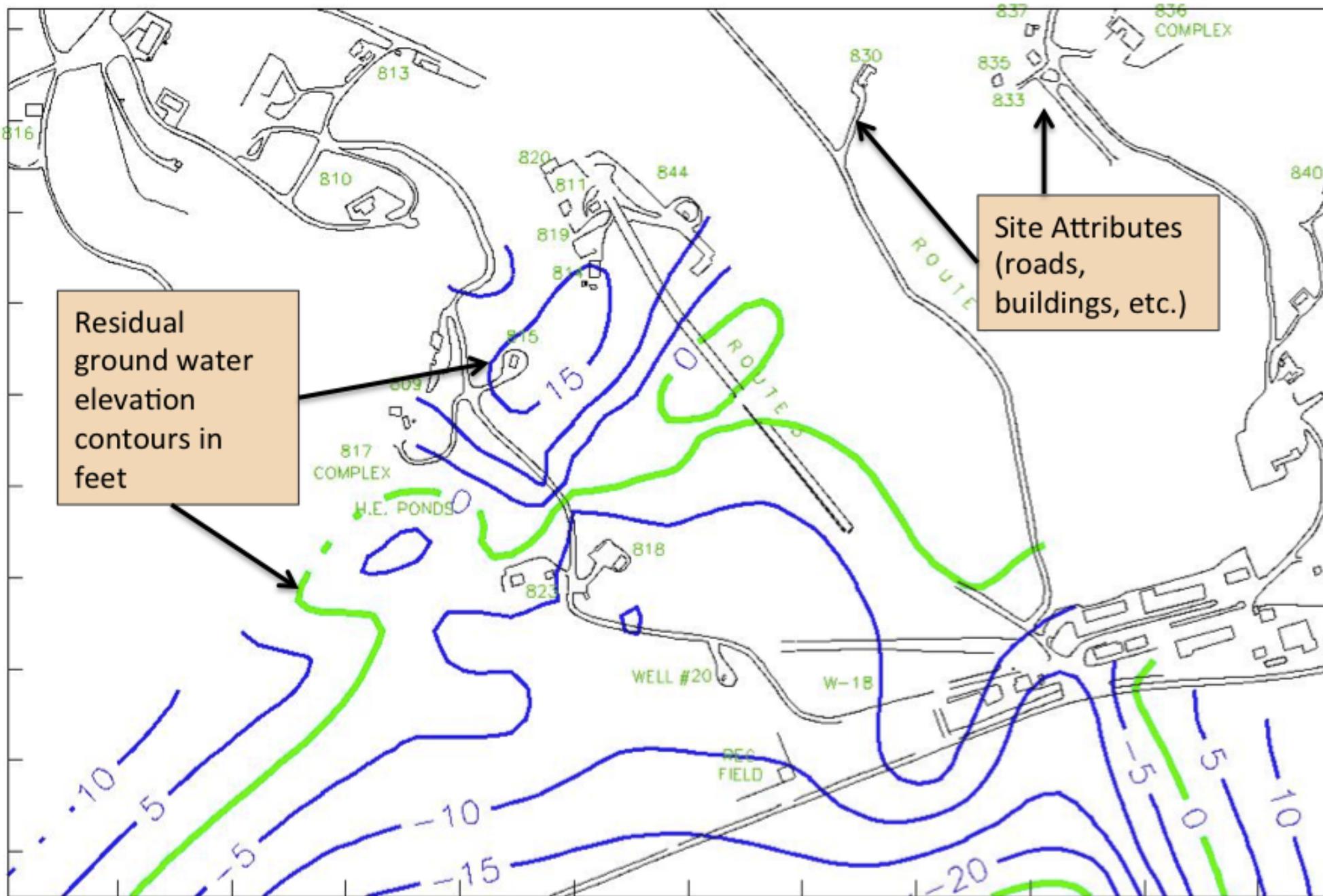
These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h)."

- 6. Section 5.3 (Results), items 2 and 3:** Use a different term than "codified" in both instances, as the inclusion in the final ROD is not a "codification."

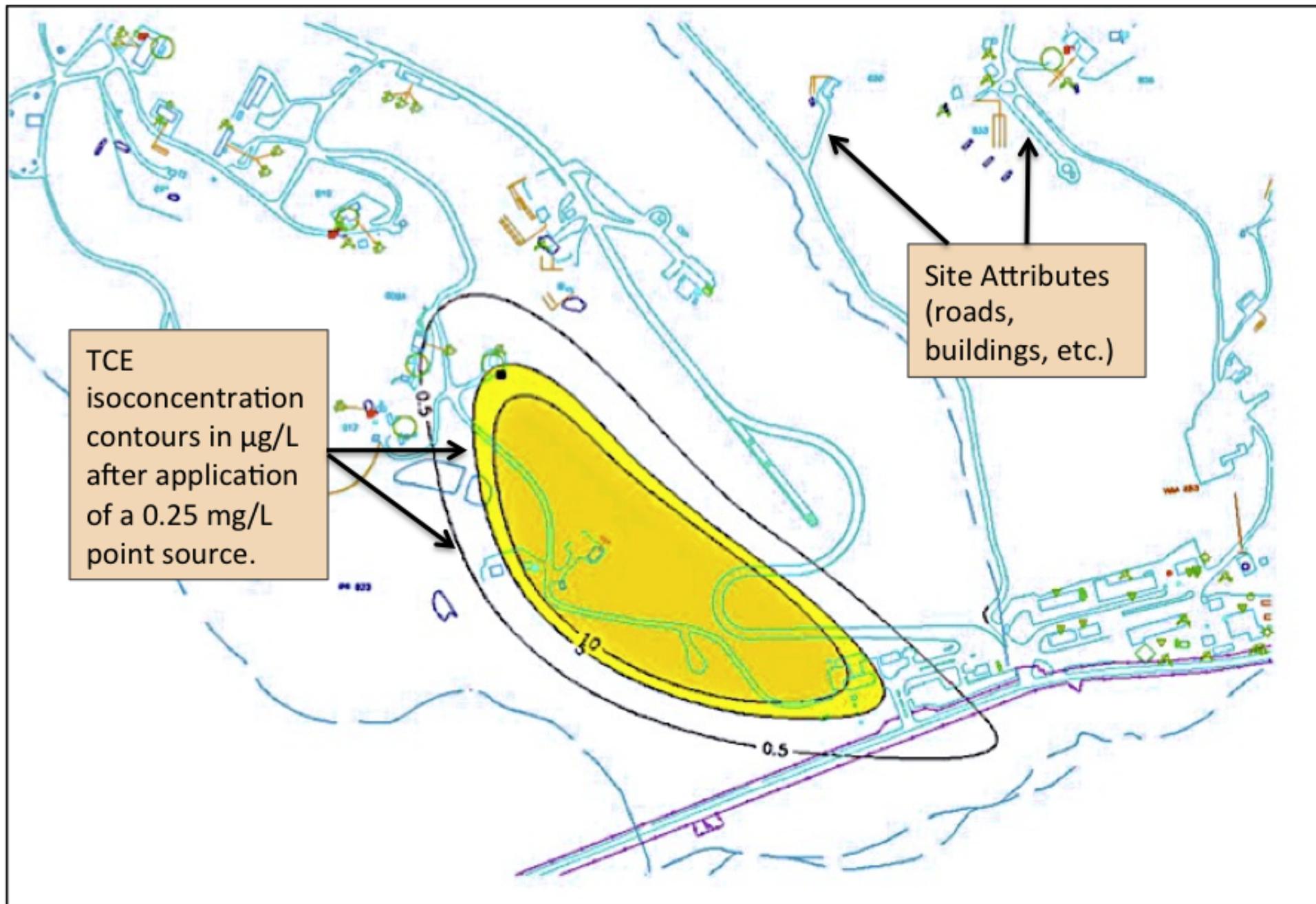
Response: In Section 5.3 (Results), the term "codified" in items 2 and 3 has been changed to "...was included as a requirement in the 2008 Final Site-Wide ROD."

- 7. Section 10 (Protectiveness Statement):** The text should be revised to note upfront, that the remedy is protective in the short-term, but not the long-term.

Response: The 1st paragraph of Section 10 (Protectiveness Statement) has been replaced with the following text: "The remedy at the HE Process Area OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination and remedial treatment systems are effectively treating ground water. Exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. However, in order for the remedy to be protective in the long-term, institutional controls will be implemented to prevent potential future exposure to offsite ground water contamination."



Attachment 1: Contours showing the difference between measured and modeled ground water elevations in feet in the Tnbs₂ hydrostratigraphic unit.



Attachment 2: Distribution of TCE in the Tnbs_2 hydrostratigraphic unit after application of a 0.25 mg/L point source applied at Building 815 for 25 years, discontinued and then allowed to migrate for another 30 years.

Responses to the U.S. Environmental Protection Agency (EPA) Comments for the Draft Final Five-Year Review Report for the High Explosives (HE) Process Area Operable Unit (OU) at Lawrence Livermore National Laboratory (LLNL) Site 300

Additional comment sent via e-mail by the EPA Remedial Project Manager (RPM) Andy Bain on March 5, 2013:

- 1. Response to EPA Draft Final Comment 8:** The response partially addresses the comment. The response states, “As...indicated in the data depicted in Attachment 1, the model was able to match the general pattern of groundwater elevations with some differences near the model boundaries,” but Attachment 1 indicates that there is spatial bias in the model. Specifically, Attachment 1 depicts consistent positive residuals between the Building 817 complex and Building 844, with more than 15 feet of residual head difference between Buildings 815 and 814, while all of the residuals south, southeast, and southeast of Buildings 818 and 823 are negative. If the residuals represent the difference between measured groundwater elevations and predicted groundwater elevations (i.e., measured-predicted) as indicated by the text on Page A-4 of the Draft Final HEPA Five-Year Review Report, the result of this spatial bias is to flatten or underestimate the modeled horizontal hydraulic gradient. As a result, the groundwater flow velocity and rate of contaminant plume migration would also be underestimated. This should be acknowledged in the text. Also, the next time the model is run, every attempt should be made to minimize this spatial bias. This issue needs to be addressed the next time the model is run. We recommend discussing an upcoming meeting.

Response: The U.S. Department of Energy and Lawrence Livermore National Security (DOE/LLNS) agree that spatial bias exists in the model, especially near the boundaries. Residuals represent the difference between measured and predicted groundwater elevations (measured – predicted) resulting in a flatter ground water gradient near the source areas. As a result, the ground water flow velocities and rate of contaminant plume migration may be underestimated in these areas. The calibration of this model will be improved to minimize the spatial bias before using this model again for the next Five-Year Review for this OU. Per a discussion and agreement between the EPA RPM and DOE RPM, text will not be added to this Five-Year Review in order to finalize the report.



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